

MotorPro™ Training

Fractional HP Motors



Training Outline

- Electric Motor Basics
- Applications
- Induction Motor Types
- Induction Motor Parts
- The Nameplate Tells a Story
- Identifying the Unknown Soldier
- Post Mortems

Electric Motor Basics

- Volts - The unit of measure of the electrical pressure available to force electricity through a motor.
 - Common U.S. voltages are 115, 208, 230, 277 & 460. Motors should operate at voltages within 10% of nameplate rating. A 230 volt motor should work at 208 volts.
- Amps - The unit of measure of the flow of electricity into a motor.
 - Usually regarded as a good indicator of strength, but can be misleading due to efficiency and power factor.

Electric Motor Basics

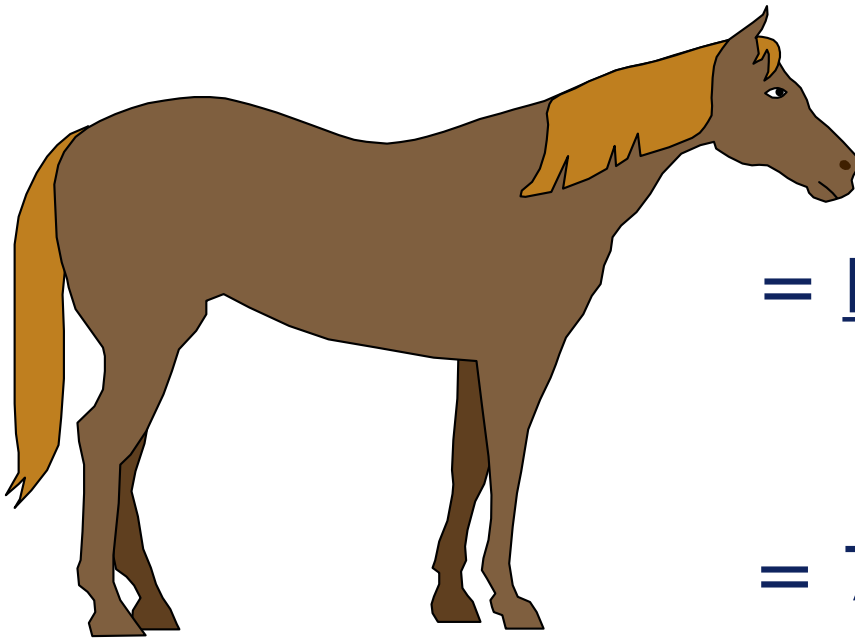
- Watts - Amount of energy used by a motor. 1000 watts used in an hour is a kilowatt-hour. This is what you pay for.
 - Watts used can be calculated by the Amps X Volts X Power Factor.
- Power Factor - A relationship of the timing of the Volts and the Amps. It is never greater than one. It is dependent on the motor type, size, number of poles and, with some motors, the size of the run capacitor.
 - Bigger Cap = Larger Power Factor = Lower Amps.

Electric Motor Basics

- Torque - Twisting force produced by most motors.
- Horsepower - The amount of energy a motor can produce. Motors can also be rated in Watts.
 - 1 horsepower equals 746 watts. Horsepower is proportional to torque X speed (RPM).
 - Note that a 1 HP motor which runs 3600 RPM only has to produce 1/3 of the torque that a 1 HP motor which runs 1200 RPM.
 - The extra torque needed necessitates that the motor be mechanically stronger.
 - Also the slower speed of the 1200 RPM means that the motor cannot cool itself as well.
 - Both of these add up to the 1200 RPM, 1 HP being more expensive (and heavier) than the 3600 RPM, 1 HP.

Electric Motor Basics - Horsepower

1 HORSEPOWER



$$= \frac{\text{RPM} \times \text{TORQUE (OZ-FT)}}{84,000}$$

$$= 746 \text{ WATTS}$$

Electric Motor Basics - Efficiency

- Efficiency - The ratio of power out to power in. The difference is the heat generated by the motor.
 - This additional heat produced by a less efficient motor can shorten the motor life.
 - The additional heat can also put a greater load on air conditioning systems.
 - Both of these factors will add to greater costs in the long run.

Electric Motor Basics - Efficiency

$$\text{EFFICIENCY} = \frac{\text{POWER OUT}}{\text{POWER IN}}$$

70% EFFICIENCY

1 HP

OR

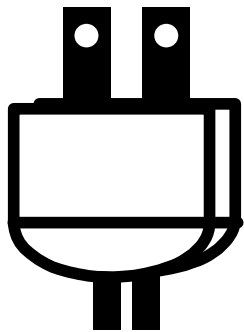
746 WATTS

320

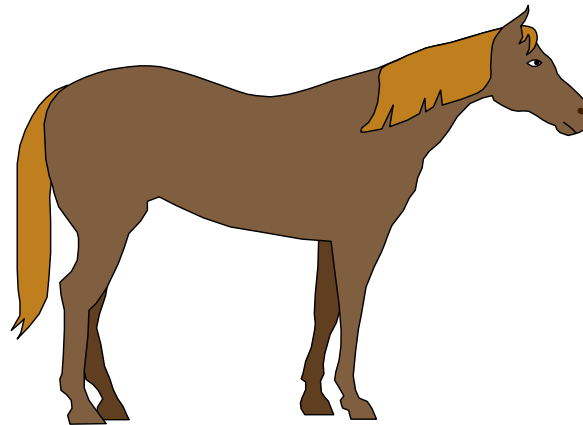
WATTS

HEAT

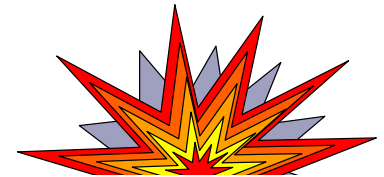
1066 WATTS



=



+



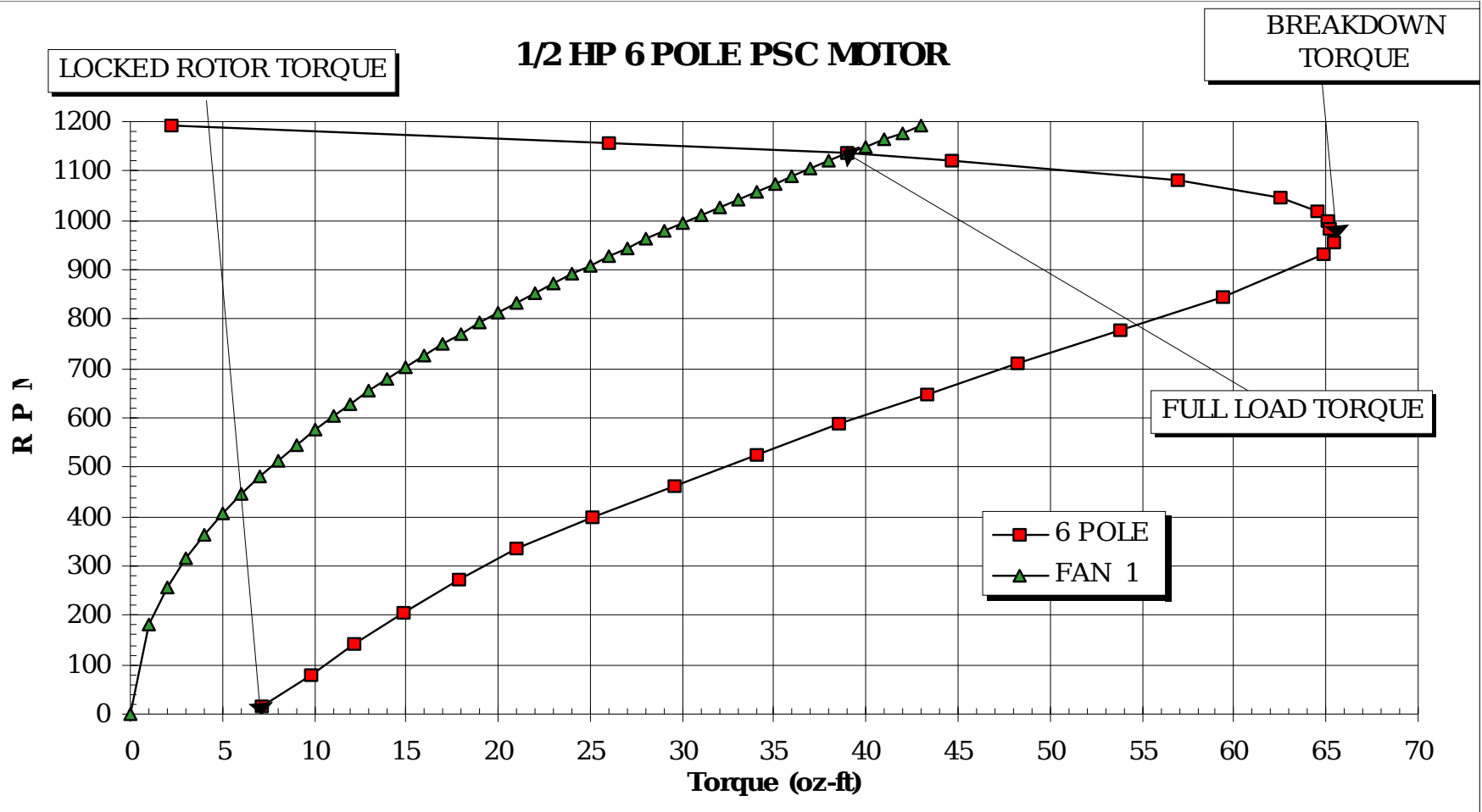
Electric Motor Basics - Speed Torque

- A speed - torque curve - The signature of how much torque a motor can deliver at a certain speed.
- Breakdown torque - The maximum torque the motor can deliver before stalling.
- Starting or Locked Rotor torque - The torque a motor has when it starts to rotate.
- Full Load torque - The torque the motor develops at rated horsepower and speed.

Electric Motor Basics

Speed-Torque Curve

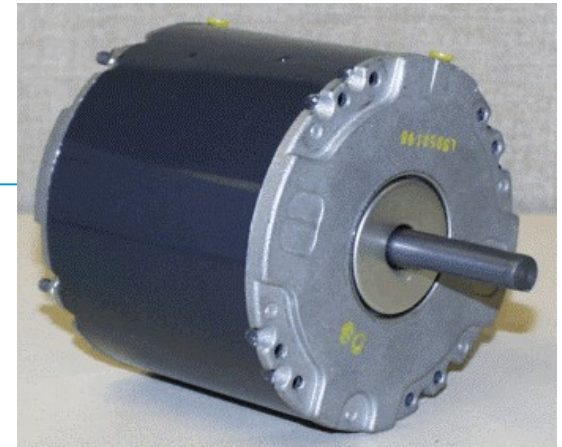
1/2 HP 6 POLE PSC MOTOR



HVAC Applications

- HAC
 - Condenser Fan
 - Direct Drive Blower
 - Single Shaft – Furnace/Air Handlers
 - Double Shaft – Fan Coils
 - Belt Drive Blower
 - Room AC
 - Evaporative Cooling
- Refrigeration – Condenser Fans
- Ventilation
 - Commercial Fans
 - Oven
 - Ag Fans
 - Commercial Ventilators
 - Air Curtains
 - Power

HVAC Applications



- Condenser Fans
 - Usually Totally Enclosed.
 - Need Drain Holes.
 - Usually Vertical Mount – Stud or Ear mount.
 - High Ambient: 140F = 60 C.
 - Usually Direct Drive/Air Over.
 - 6 Pole is Most Common. 8 Pole Increasing. Some 4 Pole.
 - Multi-Speed is Not Common.
 - Speed Controlled Applications are Special.

HVAC Applications

- Direct Drive Blower – Single Shaft
 - Usually Completely Open
 - Horizontal Mount - Belly Band or Flex Mount; Some Resilient Ring
 - Low Ambient: 77F = 25 C; Air Over
 - Multi-speed Is Common
 - Noise Sensitive
 - 6 Pole Is Most Common. Very Few 8 and 4 Pole.

Variable Speed Drives Growing.



HVAC Applications

- Direct Drive Blower – Double Shaft
 - Usually Completely Open
 - Horizontal Mount - Most Resilient
 - Low Ambient: 77F = 25 C; Air Over
 - Multi-speed Is Common
 - 4 & 6 Pole Are Common
 - Very Long Shaft Extensions, Some 3/8"
 - Still Some Shaded Pole



HVAC Applications

- Belt Drive Blowers
 - Usually Open Drip proof
 - Usually Horizontal Resilient Mount
 - Noise Sensitive
 - Can be Either Split Phase or Cap Start
 - Mostly 4 Pole, Very Few 2 Pole, Some 4/6 pole



HVAC Applications

- Room AC
 - Usually Totally Enclosed at OEM
 - Horizontal Mount – Bracket, Stud, or Resilient Ring
 - Moderately High Ambient: 113F = 45 C
 - Air Over
 - Noise Sensitive
 - Multi-Speed
 - 6 Pole Poles. Some Low Speed 4 Poles Used.



HVAC Applications

- Evaporative Cooling (Swamp Cooler, Desert Cooler)
 - Usually Drip proof-Belt Drive.
 - Open-Direct Drive.
 - Not High Ambient: Less Than 104F = 40 C.
 - Resilient Mount-Belt Drive.
 - Belly Band or Flex Direct Drive.
 - Belt Drive is Usually 4/6 Pole Split or Cap Start.



s Multi-Speed PSC.

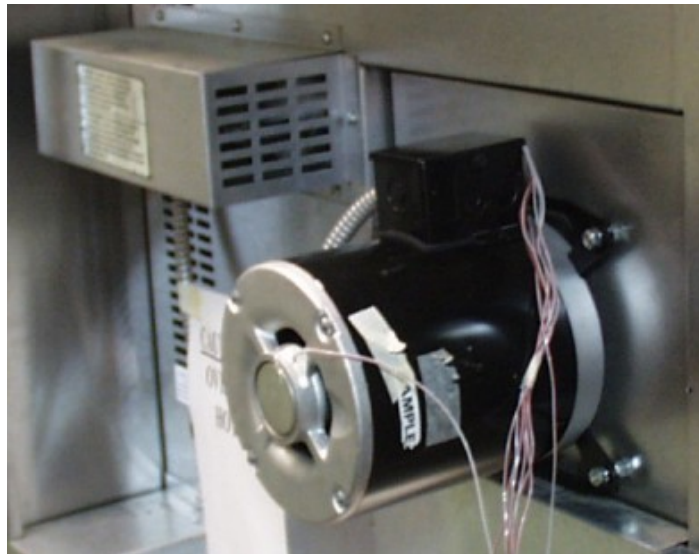
HVAC Applications

- Refrigeration Condenser Fan
 - Can Be Totally Enclosed.
 - Some Are Drip Proof.
 - Horizontal Mount.
 - Resilient Mount for Larger Hp (Over 1/15).
 - PSC for Larger HP.
 - Screw Mount for Smaller HP.
 - Shaded Pole for Smaller HP.
 - Not Usually High Ambient: Less Than 104F = 40 C
 - Direct Drive Air Over.
 - Some 4, 6 and 8 Poles.



HVAC Applications

- Ventilation, Commercial Fans
 - Ovens
 - Can Be Open or Enclosed
 - Ball Bearing
 - Direct Drive, No Air Over
 - Proof of Rotation Sometimes Needed
 - Unique Mountings Can Pose Tooling Issues



HVAC Applications

- Ventilation, Commercial Fans
 - Ag Fans
 - Mostly Enclosed
 - Can Be Either Belt or Direct Drive
 - Ball Bearing
 - Can Be Air Over
 - Mostly Resilient Mount



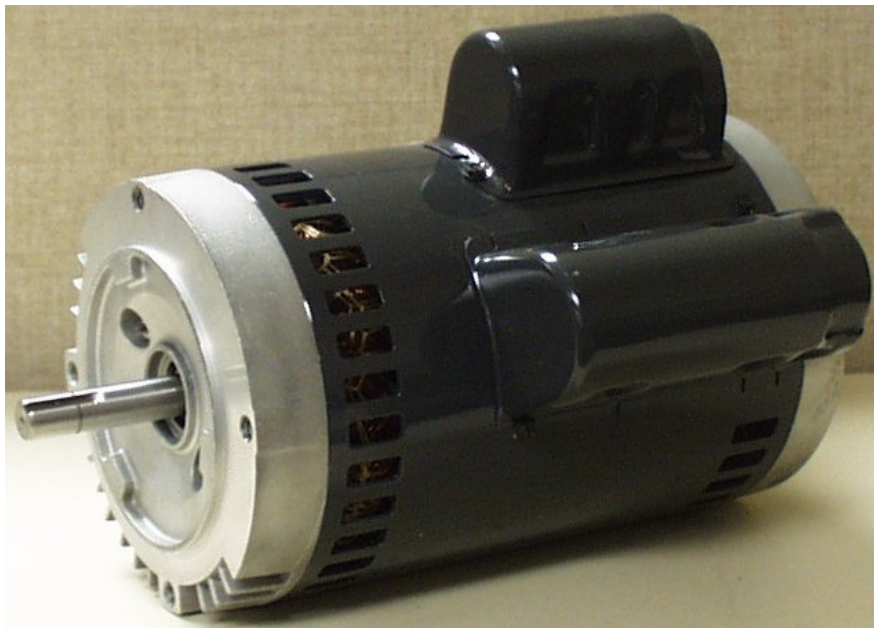
HVAC Applications

- Ventilation, Commercial Ventilators
 - Air Doors
 - Mostly Enclosed
 - Ball Bearing
 - Direct Drive, Air Over
 - Resilient Mount, Double Shaft



HVAC Applications

- Ventilation, Commercial Ventilators
 - Power Ventilators
 - Can Be Open or Enclosed
 - Ball Bearing
 - Direct Drive or Belt Drive, No Air Over
 - Most Are Resilient Mount; Some Face Mount



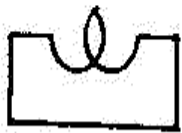
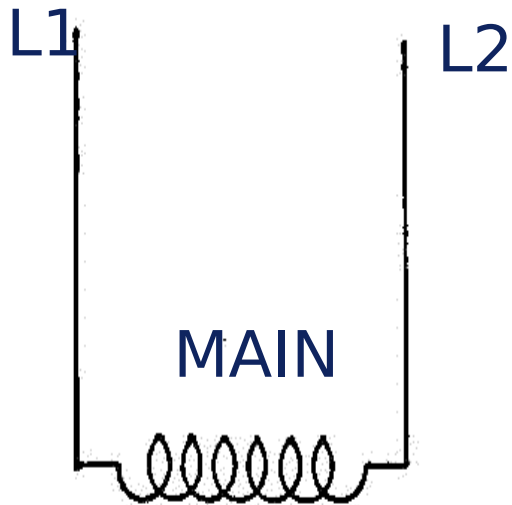
Induction Motor Types

- Shaded Pole
- Permanent Split Capacitor
- Split Phase
- Capacitor Start
- Capacitor Start-Capacitor Run
- Three Phase

“Universal” Type Motor Examples



Induction Motor Types - Shaded Pole



SHADING COILS



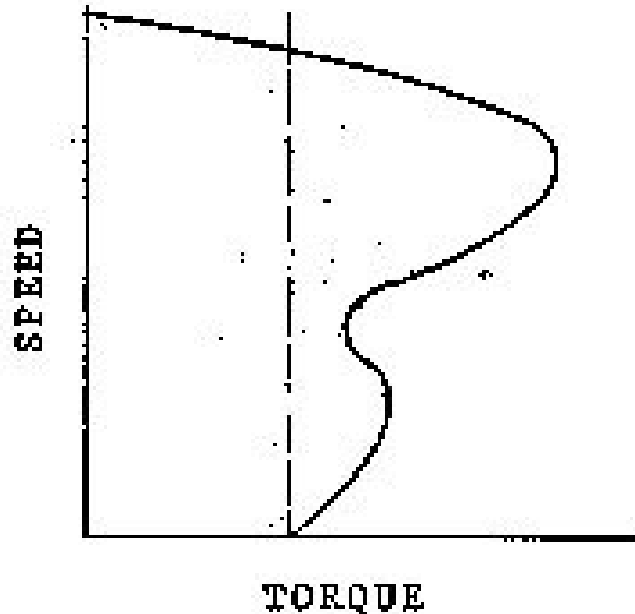
Advantages: Simple and reliable. Low cost.

Disadvantages: Very poor efficiency. Much heat generated in higher HP's. Very Low starting torque. Multi-speed is so-so.

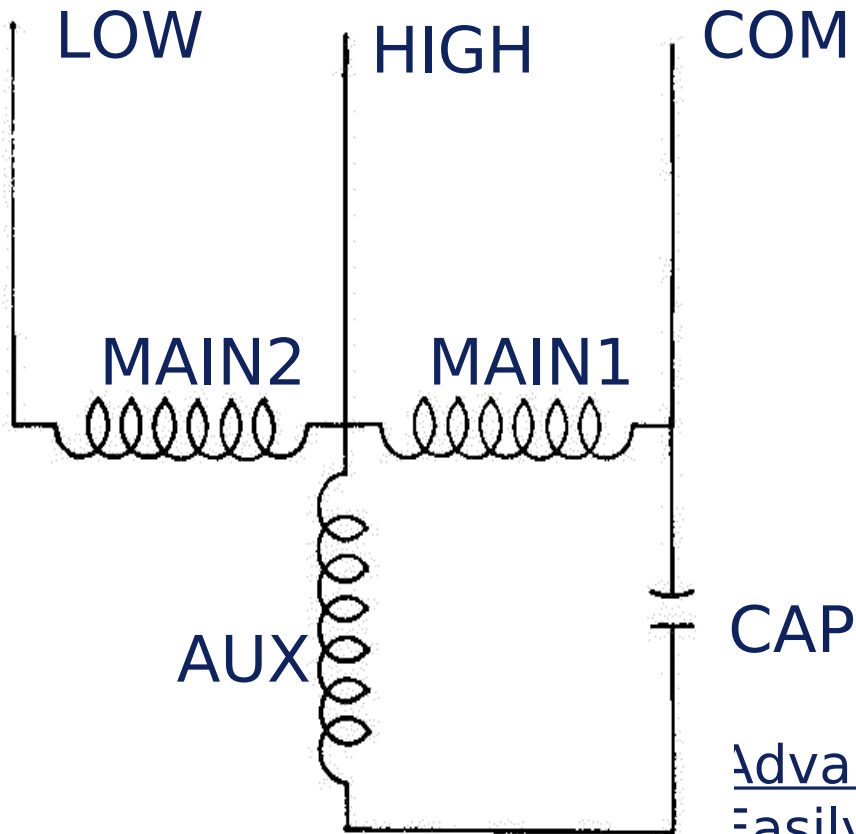
Horsepower: Up to 1/3: best less than

Induction Motor Types - Shaded Pole

- Max Efficiency: 35%.
- Max Power Factor: 60%.
- Common Failure Modes: Bearings and open winding.



Induction Motor Types - PSC



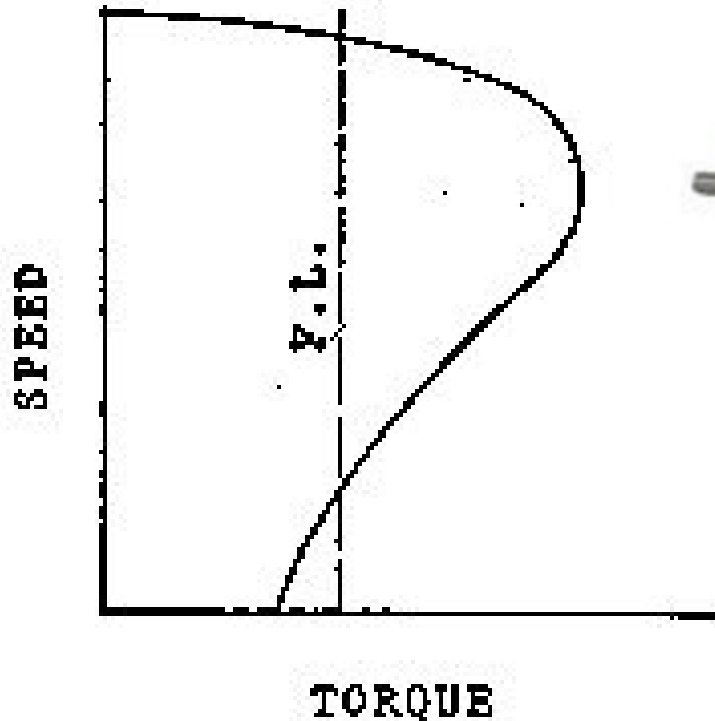
Advantages: High Efficiency. Low Current.
Easily adapted for multi-speed.

Disadvantages: Low starting torque.
Needs capacitor. Moderate cost.

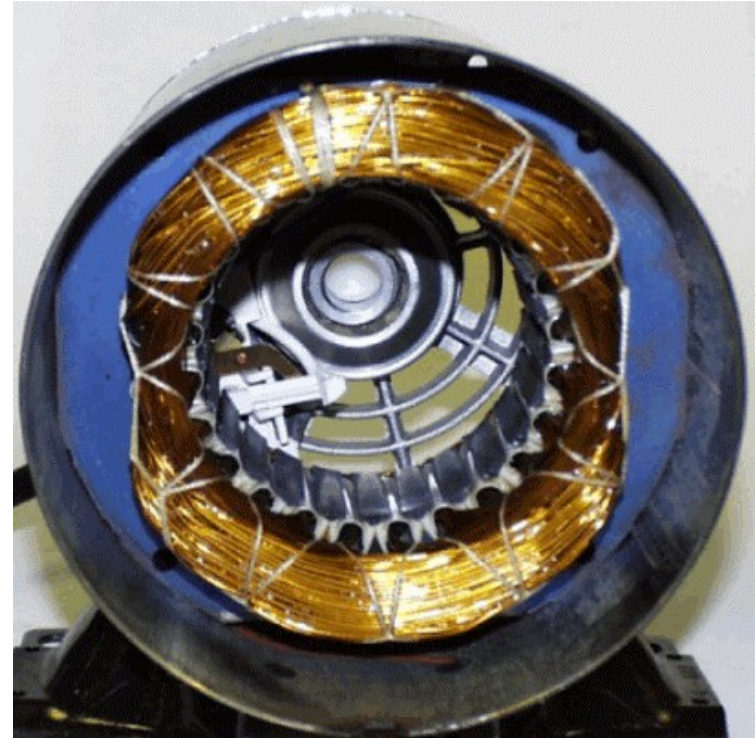
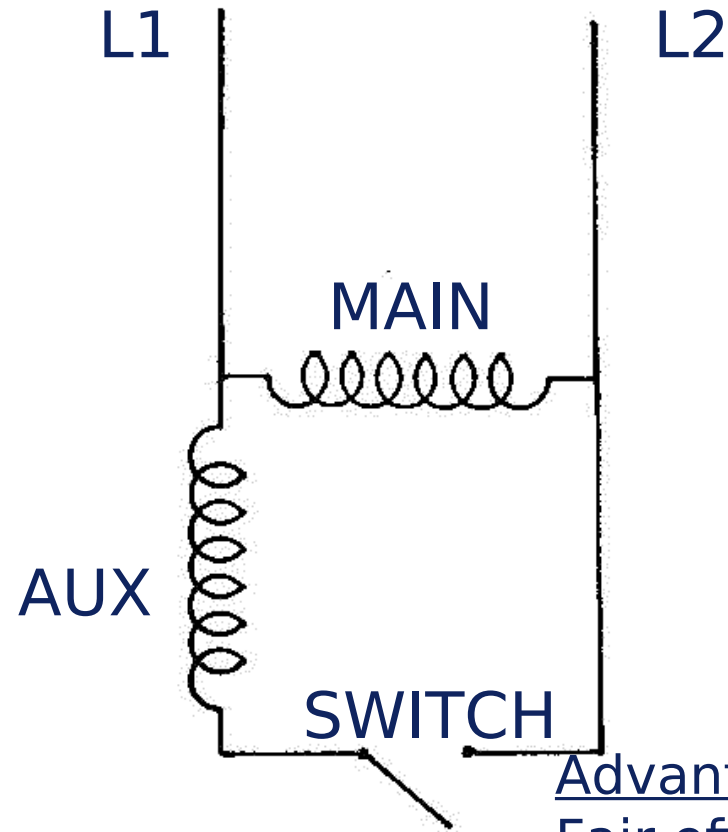
Horsepower: Up to 3 HP.

Induction Motor Types - PSC

- Max Efficiency: 75%.
- Max Power Factor: 100%
- Common Modes of Failure: Bearings, Open Main, Open Aux, Open Capacitor, Shorts to Ground and Shorts between Mains and Aux.



Induction Motor Types - Split Phase



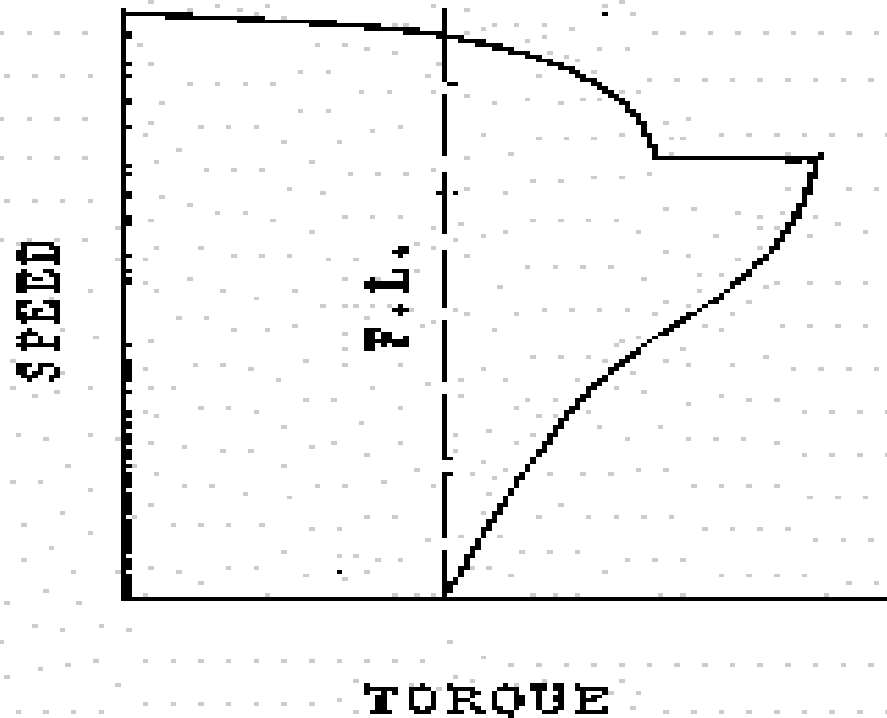
Advantages: Fair starting torque. Low cost.
Fair efficiency.

Disadvantages: High starting current. Switch needed.
Not a good dual voltage motor.

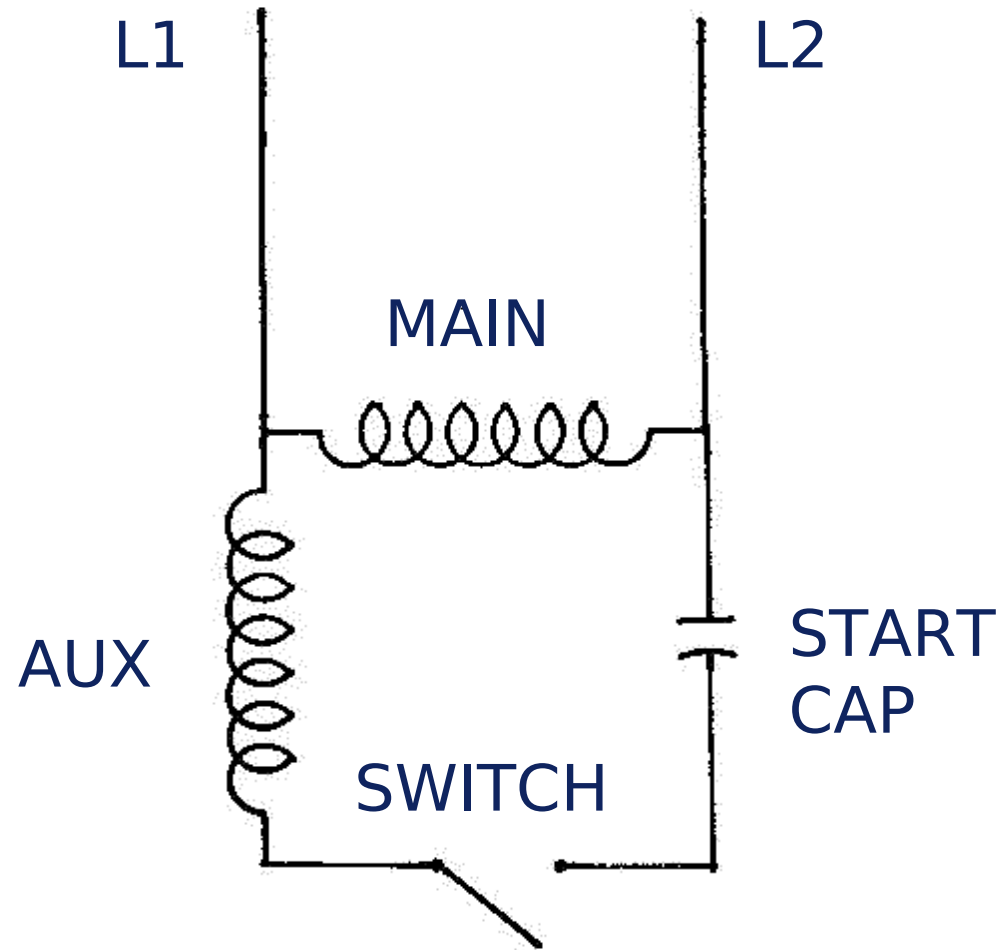
Horsepower: Up to 3/4 HP in 115 volt.

Induction Motor Types - Split Phase

- Max Efficiency: 65%.
- Max Power Factor: 70%
- Common Modes of Failure: Bearings, Open Main, Open Aux, Starting Switch Stays Open or Closed.



Induction Motor Types - Cap Start



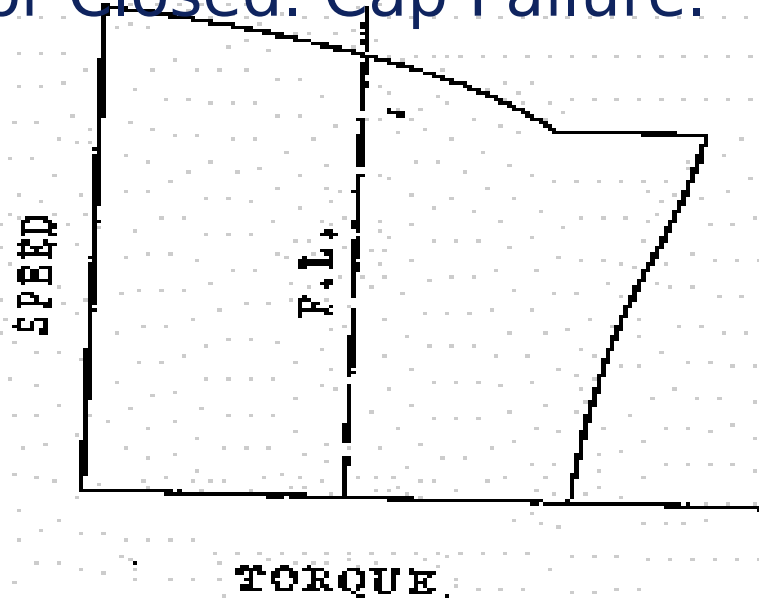
Advantages: High starting torque. Low starting current. Moderate Efficiency.

Disadvantages: Higher cost. Start capacitor and switch needed.

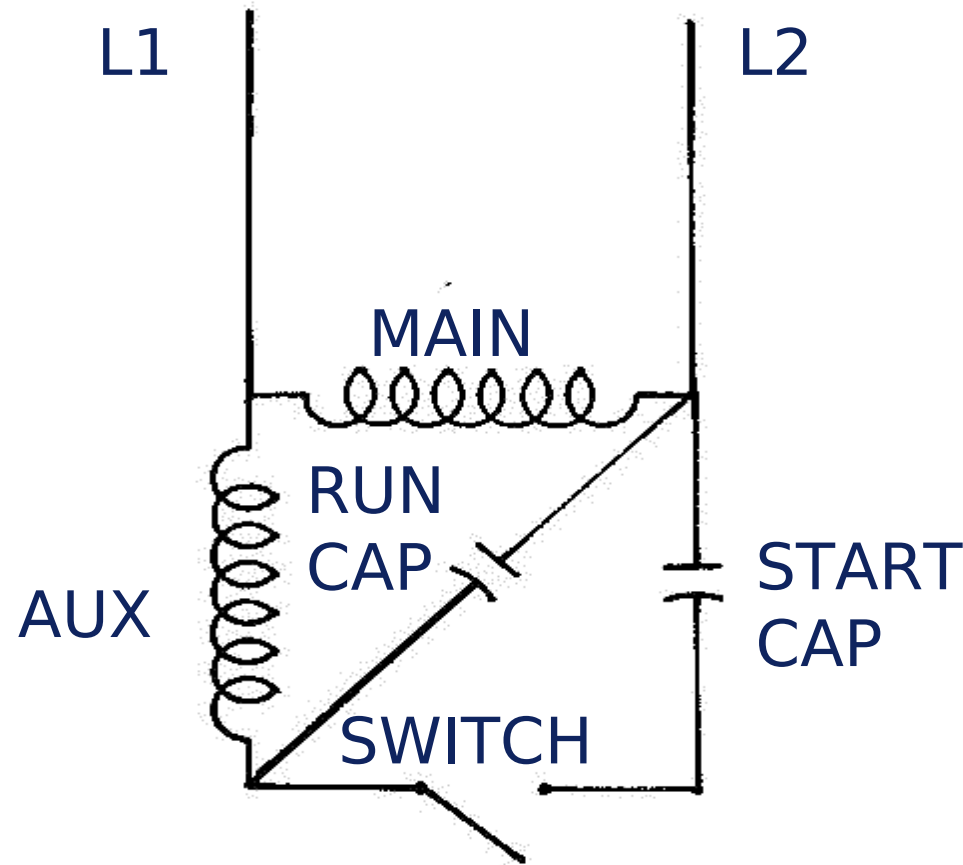
Horsepower: Up to 2 HP.

Induction Motor Types - Cap Start

- Max Efficiency: 65%.
- Max Power Factor: 70%
- Common Modes of Failure: Bearings, Open Main, Open Aux, Starting Switch Stays Open or Closed. Cap Failure.



Induction Motor Types - Cap Start & Run



Advantages: High starting torque.

Low starting current. High efficiency.

Low running current.

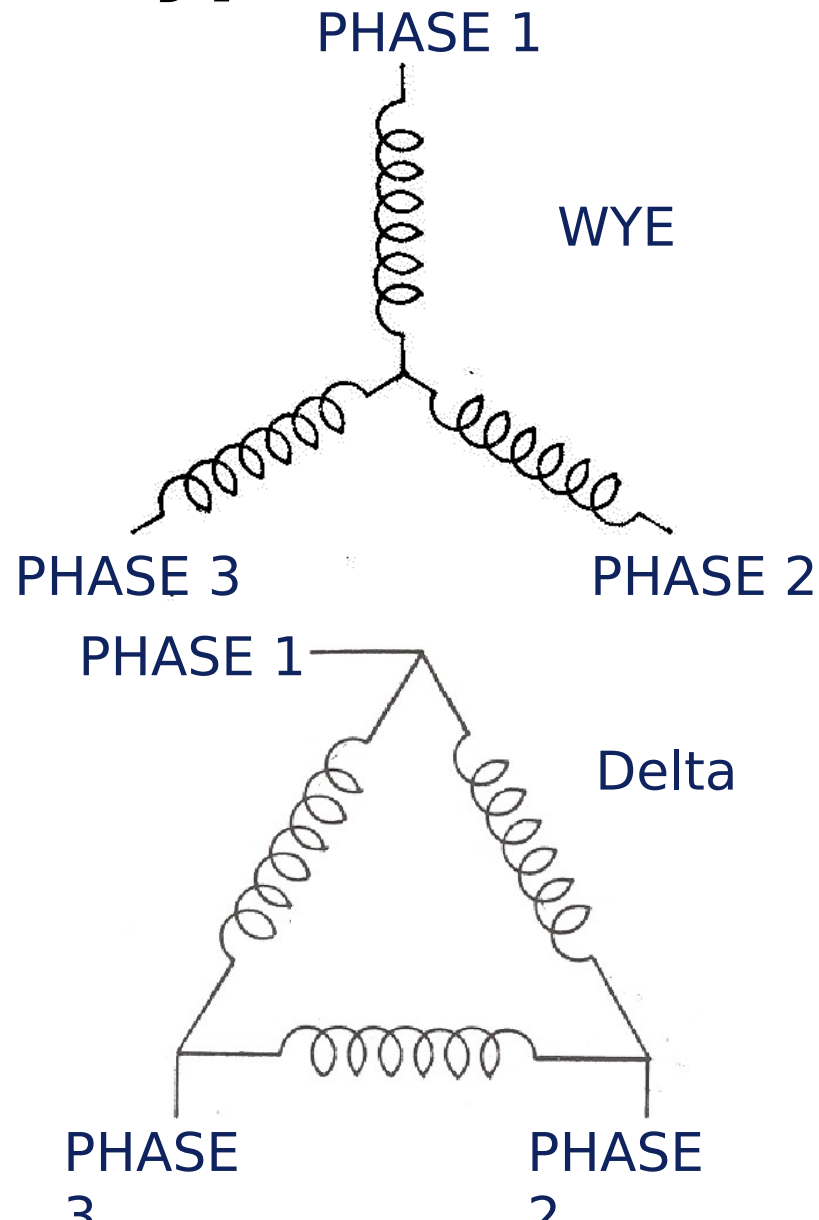
Disadvantages: Highest cost. Two capacitors and switch needed.

Induction Motor Types - Cap Start & Run

- Max Efficiency: 75%.
- Max Power Factor: 100%
- Common Modes of Failure: Bearings, Open Main, Open Aux, Starting Switch Stays Open or Closed. Cap Failures.



Induction Motor Types - Polyphase



Advantages: High efficiency.
High starting torque.
No extra electrical components needed.

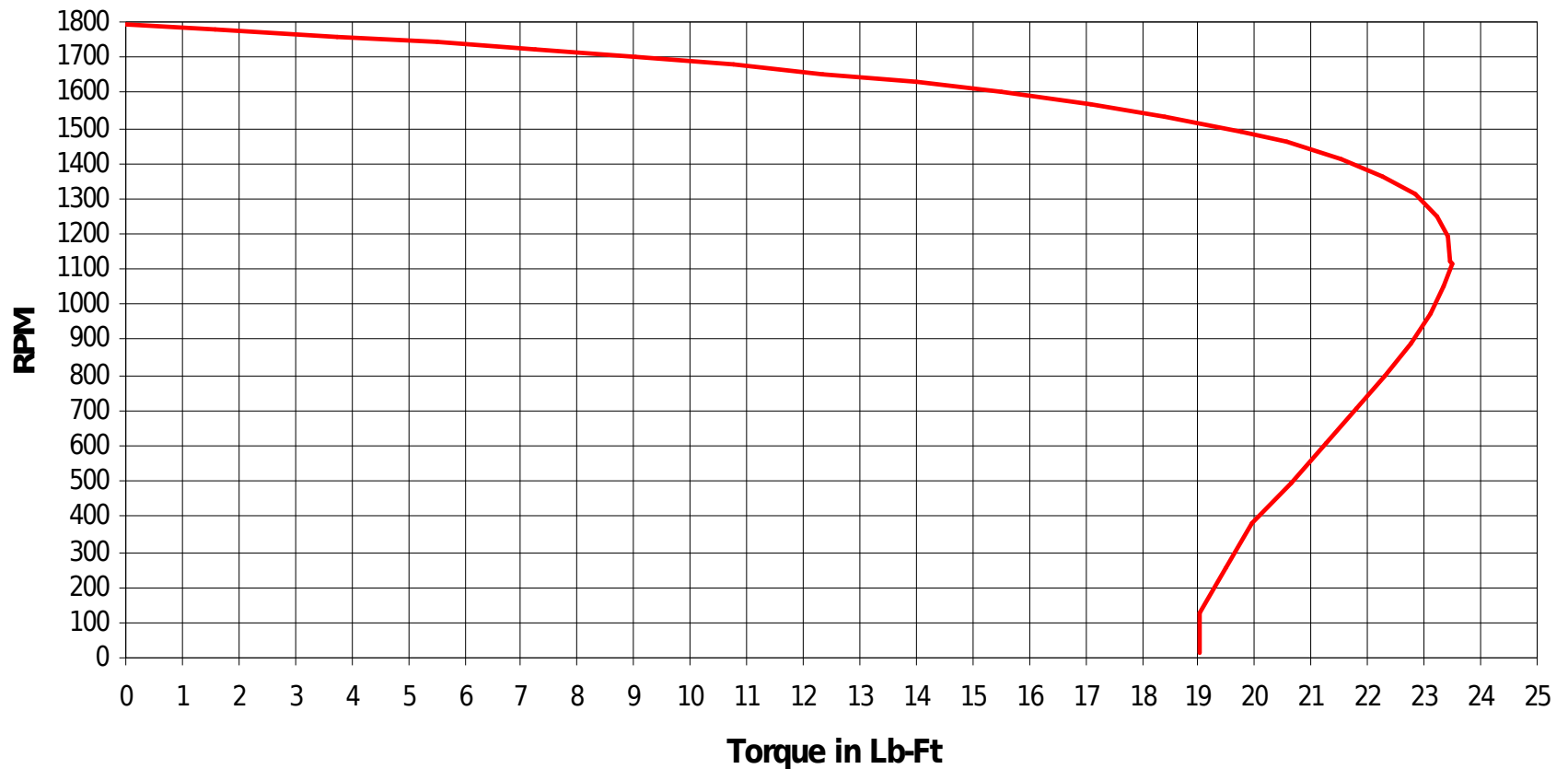
Disadvantages:

Must have 3 phase power.

Horsepower: Larger condenser fans and air handlers. Up to thousands.

Induction Motor Types - Polyphase

Speed versus Torque



Induction Motor Types - Polyphase

- Max Efficiency: 85%.
- Max Power Factor: 90%
- Common Modes of Failure: Bearings, Open Phase, Phase to Phase Shorts, Phase to Ground Short.



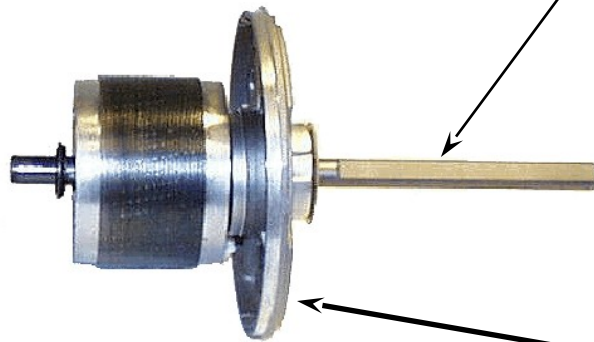
Motor Application Matrix

Motor Type	Horse Power Range	Relative Speed	Typical Uses	Characteristics		
Shaded Pole	1/3 to 1 HP	825	Very Low	Small Fans	Freezer Blowers	Light Duty for Small Loads
	1050	Unit Heaters	Small Exhaust Fans		Air Over Design Usually Required	
	1550	Humidifiers	Portable Evap Coolers	Single Voltage, Usually		
	3000	Floor Fans	Space Heaters	Non-Reversible		
Permanent Split Capacitor	Up to 1.5 HP	825	Low	Shaft Mounted Fans and Blowers		More Efficiency and Power
	1075	Room A/C, Central A/C	Door Operators	Not For Belt Drive, as a rule		
	1625	- Condenser Fans	Farm Vent. Fans	Single Voltage and Rotation, usually		
	3250	- Evaporator Fans	- Poultry, Hogs, Cattle	Solid State Speed Control May Work		Multi
	Furnace Blowers	Window Fans				
	Unit Heaters					
Split Phase	Up to 1 HP	850	Moderate	Belted Fans, Blowers	Oil Burners	Low to Medium Starting Torque
	1140	A/C Fans, Blower	Attic Fans	No Capacitor Needed for Start-Up		
	1725	Furnace Blowers	Small Centrifugal Pumps	Belt Drive Applications OK		
	3450	Home Appliances	Small Tools	Single Voltage, Dual Voltage, usually		
	Door Operators	Lathes	Variable Speed Control will not work			
	Office Machines	Poultry Feeders				
Capacitor Starting Torque	1/6 - 10 HP	850	Moderate	Food Equipment	Gear Motors	Capacitor Provides High
	1140	Compressors	Barn Cleaners	Heavy Duty Applications		
	1725	Conveyors	Vacuum Pumps	Dual Voltage, Dual Rotation, usually		
	3450	Pumps	Manure Pumps			
3-Phase Power	1/4 HP and up	850	Moderate	Augers	Milk Coolers	All Applications Using 3 Phase
	1140	to High	Machine Tools	Elevators	Simple Construction	
	1725	Grain Stirrers	Cattle Feeders	No Capacitors, Switches or Start winding		
	3450	Ventilation Fans	Drying Fans	Dependable		
	Dual Rotation					

Induction Motor Parts

- Rotor
- Stator
- Thermal Protector
- Bearings
- End Shield
- Actuator
- Stationary Switch
- Capacitor
- Mountings

Induction Motor Parts



Rotor

The rotating part of the motor which normally includes the shaft. Most outdoor Emerson rotors have a unique oil quench finish and polished thrust washers.

End Shield

Also called end bells, end brackets. End of motor to support the bearing assembly. Can be used as mounting surface. Can be made of steel, aluminum or cast iron.

Induction Motor Parts

Stator



The portion of the motor that includes the stationary portions of the magnetic circuit and associated windings and leads.

It can include a frame or shell, winding supports and temperature detectors.

The Stator is made up of a stack of insulated laminations. The coils of wire are then wound or inserted on this stack. The length of this stack is determined by the horsepower. Outdoor motor stators are dipped in varnish for moisture protection.

Induction Motor Parts

- **Thermal Protector**
 - Device Assembled As an Integral Part of the Motor.
 - Senses Heat.
 - Has Contacts to Remove Power From Motor.
 - Protects the Motor Against Overheating Due to an Overload or Failure to Start.
 - Words, “Thermally Protected” on the Nameplate Indicate the Motor Is Provided With a Thermal Protector.

Induction Motor Parts

- **Thermal Protectors**

- Automatic Reset

A protector that resets automatically after it has cooled sufficiently. e.g. Belted fan blower motor.

- Manual Reset

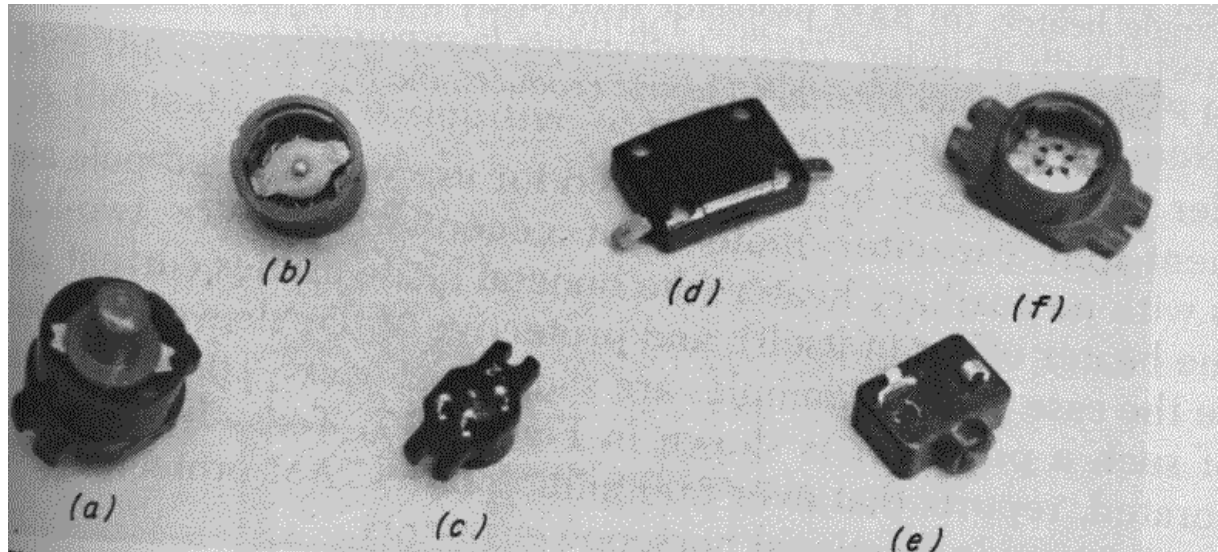
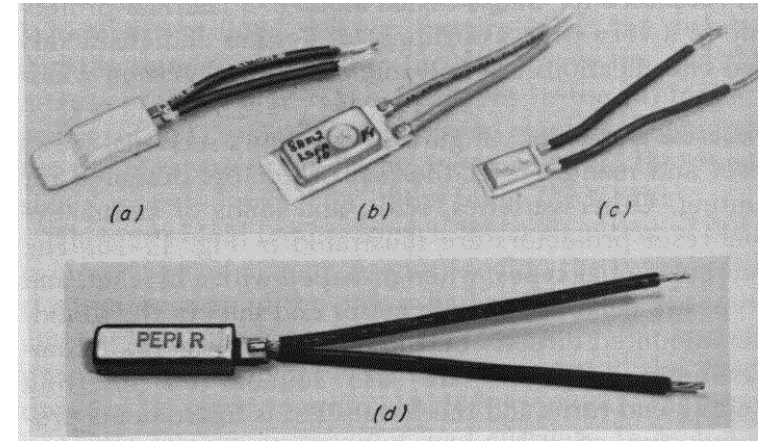
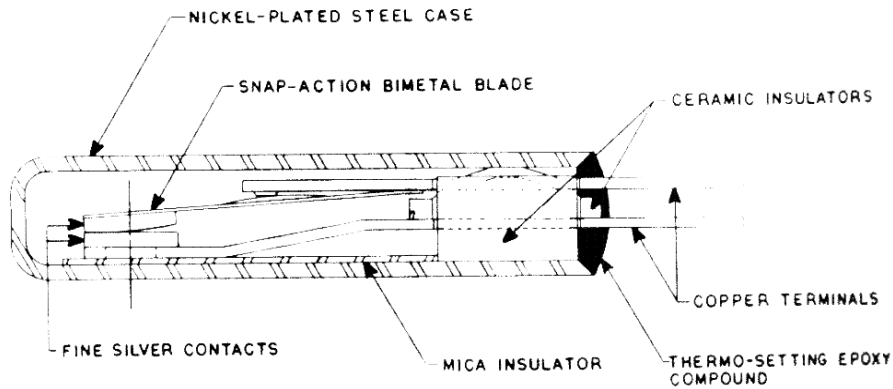
A protector, once tripped, remains open until manually reset, usually by means of an external reset button. It can not be reset until the protector has cooled sufficiently. e.g. oil burner motor and power tool motors.

- One Shot

A protector which cannot be reset. Used in attic ventilators.

Induction Motor Parts

Protectors



Induction Motor Parts

- Other Thermal Protection
 - Impedance Protection
 - Some Small Motors Have Very High Impedance (Mass).
 - Limits the Input Current Under Any Load, Including Locked Rotor.
 - Limits To a Value That Does Not Cause Dangerous Overheating.
 - Nameplate Will Note This Protection With the Words “Impedance Protected” or Possibly Abbreviated As “ZP”.
 - E.G. Unit Bearing Motor.

Induction Motor Parts

- **Bearings**

- Two Types of Bearings Used in Fractional Horsepower Motors.
- Ball Bearings
 - Motors Subject to High (25#) Thrust or Axial Loads.
 - Motors Which Must Run Very Slow (Less Than 500 Rpm).
 - Sometimes Used in High Temperature Applications (Above 185 F).
 - Usually Cannot Be Relubricated.
 - Can Be Noisy.

Induction Motor Parts

- **Bearings**

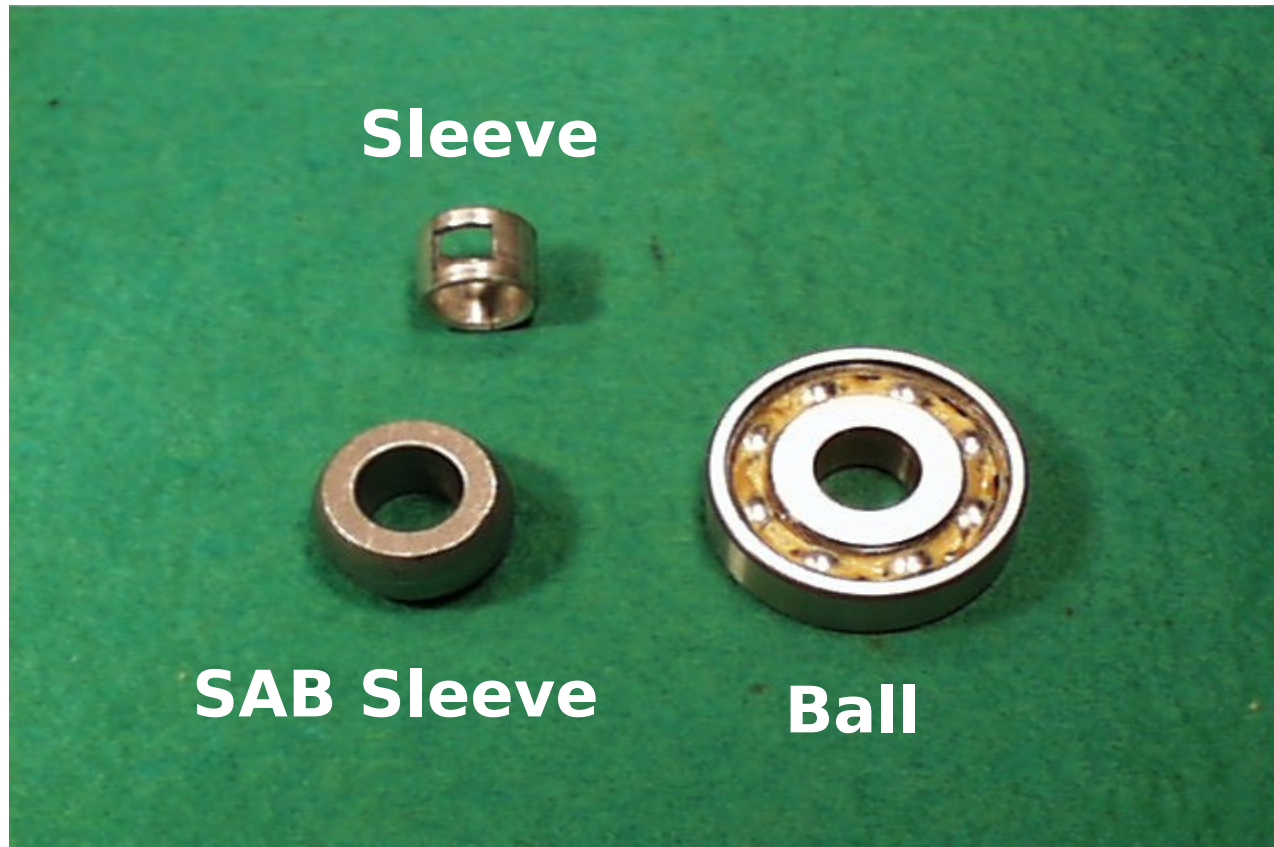
- Sleeve bearings

- Used in Motors Subject to Moderate Thrust or Axial Loads.
 - Includes Many Applications Such As Belted Fan Motors and Direct Drive Motors.
 - More Resistant to Contamination.
 - Some Sleeve Bearings Can Be Relubricated With SAE 20 Oil.
 - All Have Much More Lubrication Than Ball Bearings.
 - Quiet.
 - Can Go to High Temperature With Synthetic Oils.

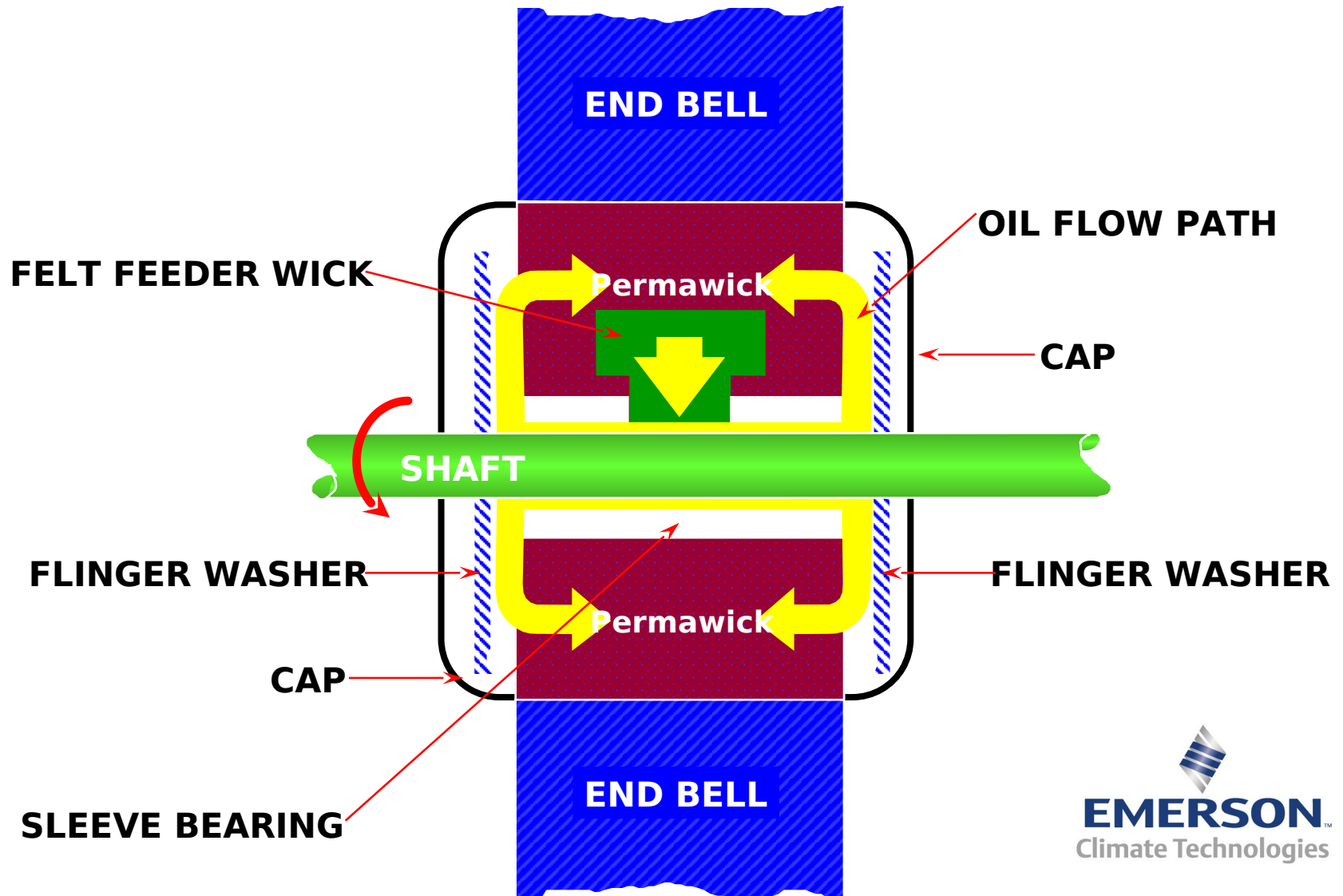
Induction Motor Parts

- Sleeve Bearings
 - Babbitt Lined Steel.
 - Not Suited to Automated Assembly.
 - Wick Window Make It Sensitive to Load Position. Cannot Load Into Window.
 - Better Radial Load Capability.
 - Runs a Little Cooler.
 - Quieter Start up Because of Faster Oil Film Buildup.
 - Easy to Make Tight.
 - Self Aligning (Iron Graphite or Bronze)
 - Easy to Automate Assembly.
 - Window Not Needed. Not Sensitive to Load Position.
 - More Resistant to Contamination.
 - More Resistant to Rough Handling.
 - Higher Friction.
 - Higher Potential for Noise.

Induction Motor Bearing Types



Typical Sleeve Bearing Oil Flow



Induction Motor Parts

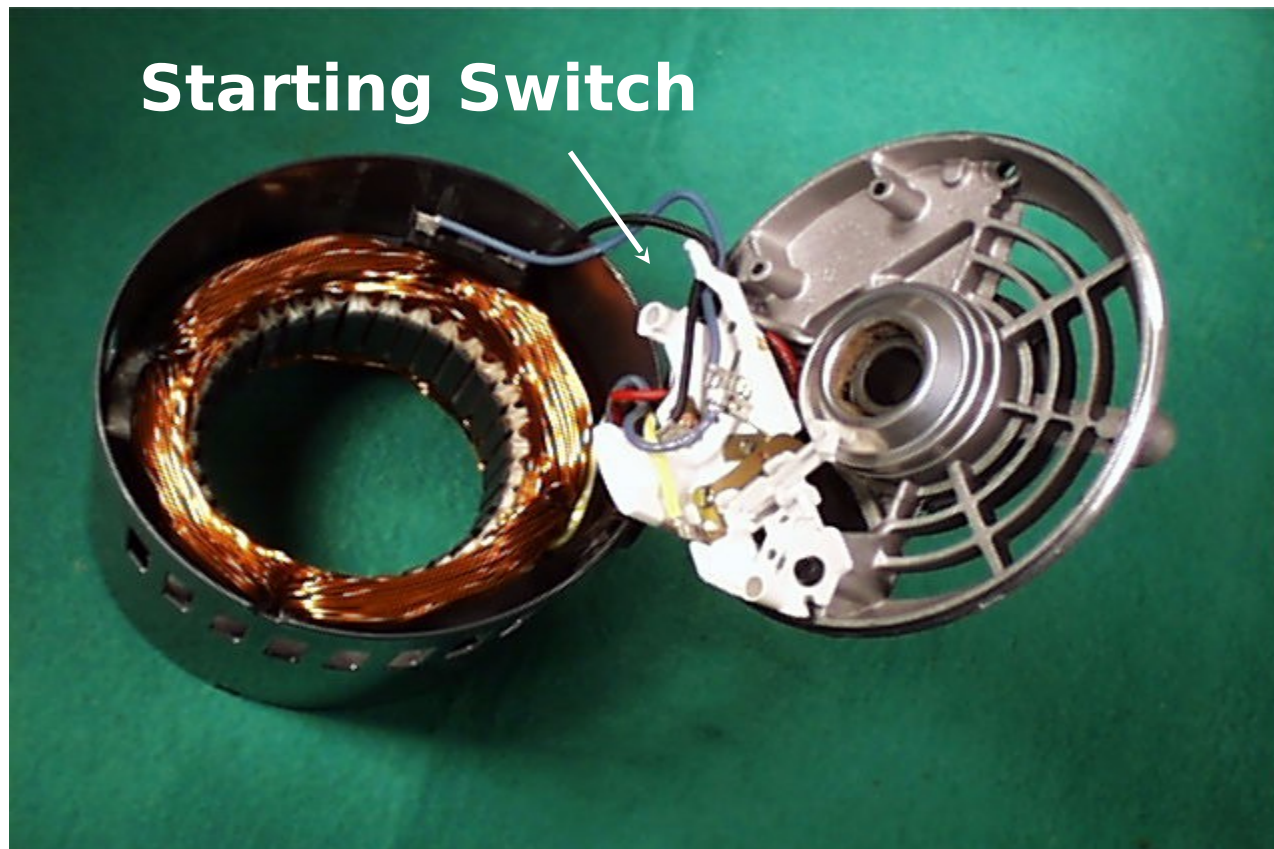
- Actuator or Rotating Switch
 - Centrifugal Device Mounted on the Rotor.
 - Used in Split Phase and Cap Start Motors.
 - Opens As the Rpm Increases.
 - Works in Conjunction With the Stationary Starting Switch.
 - When Actuator Opens, the Start Winding Is Out of the Circuit.



Induction Motor Parts

- **Starting Switch (Stationary)**
 - Stationary device mounted on the end shield or stator assembly.
 - Contains contact points and a moveable arm.
 - As the RPM increases, the centrifugal switch moves away from the starting switch, allowing the moveable arm to release from the contacts and open the circuit of the start winding.

Induction Motor Parts



Induction Motor Parts - Capacitors

- What Is a Capacitor?
 - Device With Two Internal Conductors Separated by a Insulator.
- Why Is a Capacitor Required?
 - Causes the Current to Flow Earlier in One of the Windings.
 - Makes the Motor Think It Is Being Energized by More Than One Phase.
- What Happens When a Capacitor Fails?
 - Usually Open Circuit.
 - The Motor Will Usually Not Start.
 - If It Starts, Amps Will Be Higher, and It Will Be Weaker.
 - Motor May Start in Wrong Direction.
 - Very Old Capacitors Sometimes Fail by Acting Like a Smaller or Weaker Capacitor.

Induction Motor Parts - Capacitors

- **WHAT IS A RUN CAPACITOR?**
 - A Run Capacitor Is in the Circuit All the Time.
 - Works With the Auxiliary Winding To:
 - Increase Strength
 - Increase Efficiency
 - Lower the Amps of the Motor (Increase Power Factor).
 - Run Capacitor Has:
 - LOW Microfarad Value.
 - Less Than 40 and Commonly Less Than 10.
 - Run Capacitor Can Have A:
 - Round Steel Case.
 - Oval Steel Case.
 - Plastic but Not Black Round Case.

Induction Motor Parts - Capacitors

- What Is A Start Capacitor?
 - Designed to Be in the Circuit a Short Time, During Starting.
 - Can Be Started Less Than Once a Minute.
 - Works With the Auxiliary Winding To:
 - Increase Torque During Starting.
 - Lower Amps During Starting.
 - Has a High Microfarad Value,
 - Usually Over 100.
 - Commonly Over 300.
 - Has a Short Shelf Life (2 Years).

Induction Motor Parts - Capacitors

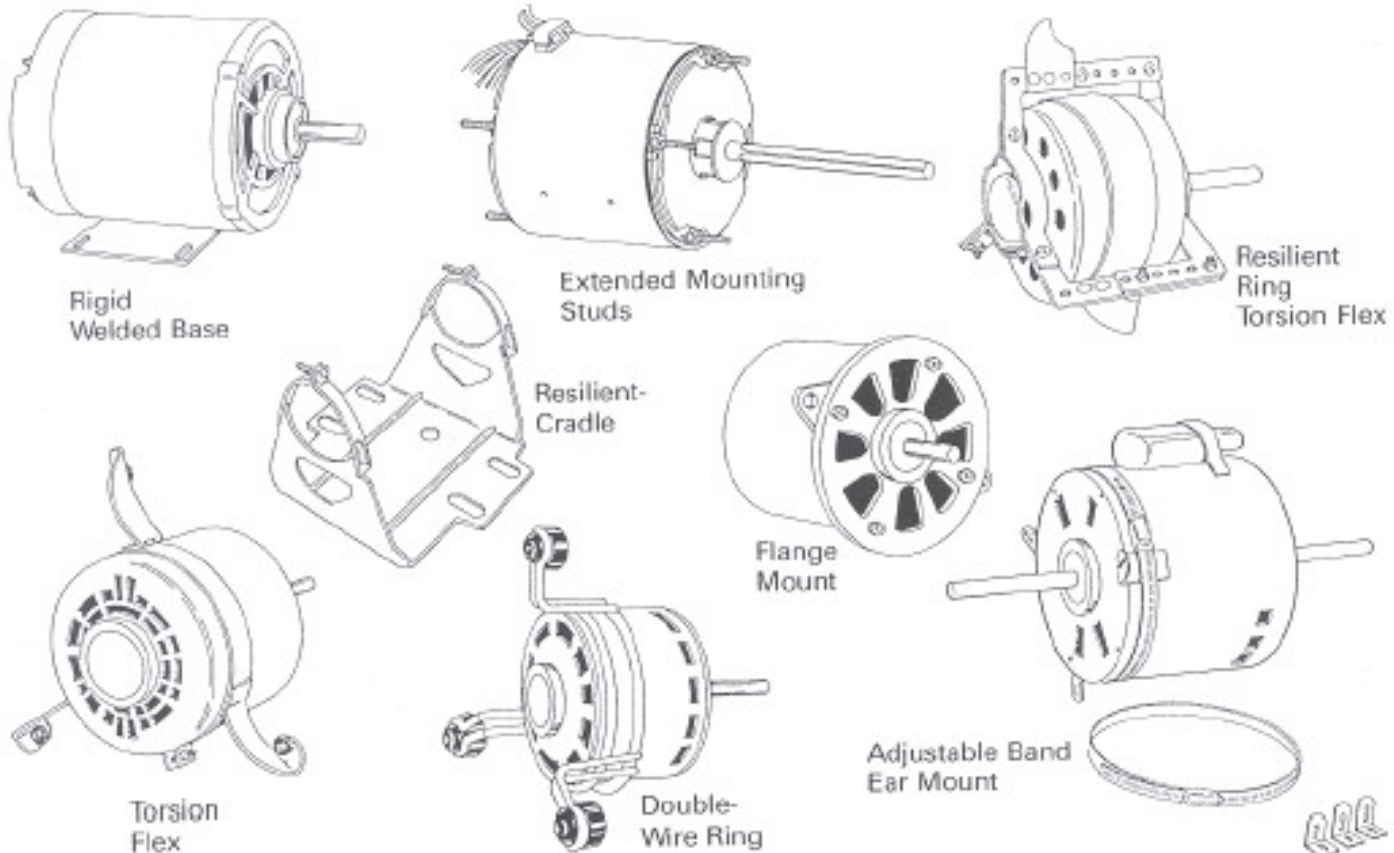
- Only replace capacitors with the same MFD rating
- Using a lower rated MFD will:
 - Result in a weaker motor
 - Lower the RPM
 - Lower the starting torque
 - Lower the efficiency
 - Create a higher AMP draw (lower power factor)

Induction Motor Parts - Capacitors

- Using a higher rated MFD capacitor will:
 - Increase starting torque
 - Increase the RPM
 - Lower the AMP draw (higher power factor)
 - Lower the efficiency
 - Increase the winding temperature
- You can use a higher rated voltage on a replacement capacitor.
 - E.g. Replace a 370 VAC capacitor with 440 VAC at the same MFD rating.

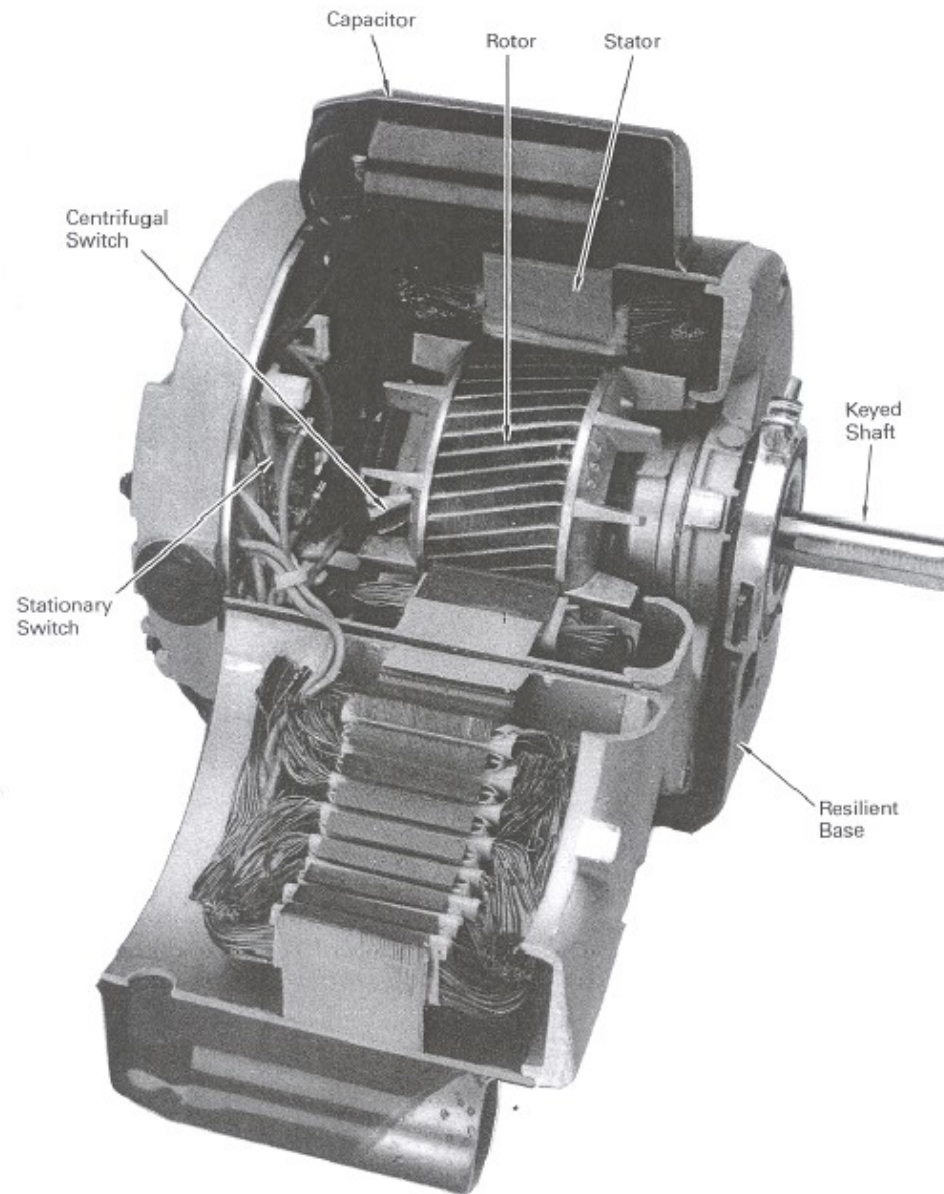
Motor Mountings

Motor Mountings



Motor Parts

Capacitor Start



The Nameplate Tells a Story

**EMERSON**

ST. LOUIS, MO U.S.A.
MODEL K48HXFKD-3865

← ROTATION

HP 1/4

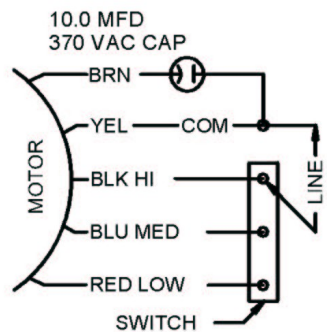
VOLT 208-230 HZ 60 AMP 1.3 PH 1

R.P.M. 1100/900/700 THERMALLY PROTECTED

PART NO SEE NOTE MFG. NO.

INS CL B 55°C AMB AIR OVER CONT FRAME 42Y

WARNING: FOLLOW ALL SAFETY INFORMATION. TO
REDUCE POTENTIAL ELECTRICAL SHOCK
DISCONNECT POWER BEFORE SERVICING. FOLLOW
NATIONAL AND LOCAL CODES FOR GROUNDING AND
INSULATE UNUSED LEAD WIRES INDIVIDUALLY.





E22922

Nameplate-Story

- Motor Numbers
 - OEM Models Will Have:
 - Model #
 - Maybe Customer Part #
 - Catalog Motors Will Have:
 - Model #
 - Catalog #
- Understanding the Model Number Can Help Identify the Type of Motor.
- The Model # Is the Most Important Piece of Information to the Motor Manufacturer.

Nameplate-Story

- Typical Emerson Model #
 - First letter describes the type of motor
 - K55HXRWS-8158
 - F = Shaded Pole
 - K, KA = Permanent Split Capacitor
 - C, CA or KS = Capacitor Start
 - P = Poly Phase
 - R or RK = Resistance Start - Capacitor Run
 - S, SA = Split phase

Nameplate- Story

Emerson

K55HXRWS-8158

└── K 55 HX RWS - 8158

Type of Electrical Motor

Dia. of stator, e.g. 5.5"

Thermal Protector

Model Code beginning with
A&S thru Z are catalog
motors. All others are OEM specific

Style #

└── 64



EMERSON
Climate Technologies

Nameplate - Story

GENERAL ELECTRIC NUMBERING SYSTEM

Indicates
Electric
Rotating
Equipment

5 KCP

Type of Motor
K - Three Phase
KH - Split Phase
KHC - Split Phase Start-
Capacitor Run
KC - Cap. Start
KCR - Capacitor Start-
Capacitor Run
KCP - Perm. Split Cap.
KSP - Shaded Pole

39

Frame Size
(Diameter)
11 - 4"
21 - 5"
29 - 5"
(NEMA 42)
30's - 5½"
(NEMA 48
& 56)
59 - 3½"
51 - 3½"
40's - 6½"
(NEMA 56)

K G

Stacking
Length
(inches of
lamination
in rotor
& stator)
A - .50"
B - .75"
C - .88"
D - 1.00"
E - 1.13"
F - 1.25"
G - 1.38"
H - 1.50"
K - 1.75"
M - 2.00"
P - 2.50"
S - 3.00"

G&N - Aluminum
K - Steel
Endshield
Construction
& Form Letter

5831

Numeric listing of
designs built in a
particular frame
size

Overload
Designation
S,T,X - automatic
reset internal
to motor
Y,U,W - manual
reset

A T

Indicates
some change
in basic
model that
does not
affect
mechanical or
electrical
interchangeability



EMERSON
Climate Technologies

Nameplate - Story

A.O. Smith

Example:

Factory model number C48J2DB5B3 (Distributor Stock Number K1052) is a single phase, capacitor start, 1/2 HP, 3450 RPM, C flange pump motor.

Factory model number F48SJ6MA5A1 is a single phase, permanent split capacitor, 48 FR., 1-1/2" stack, 6 pole, sleeve bearing, non-thru bolt motor.

The model number is arranged in 7 basic identifying segments.

C	48	J	2	DB	5	B3
(1)	(2)	(3)	(4)	(5)	(6)	(7)
F	48	SJ	6	MA	5	A1

(1) Letter code to designate general electrical design

- C - Single phase, capacitor start
- P - Polyphase
- S - Single phase, split phase
- F - Single phase, permanent split capacitor
- K - Single phase, capacitor start and run

(2) Two digits to designate frame diameter (not Nema mounting dimensions)

- 48 - Dimension 5-5/8"
- 56 - Dimension 6-9/16"

(3) Letter code to designate horsepower.

G - 1/4 HP	M - 1-1/2 HP
H - 1/3 HP	N - 2 HP
J - 1/2 HP	P - 3 HP
K - 3/4 HP	R - 5 HP
L - 1 HP	

— OR —

Stack Length

SA - 1/2	SN - 2
SB - 5/8	SP - 2 1/4
SC - 3/4	SQ - 2 1/2
SD - 7/8	SR - 2 3/4
SE - 1	SS - 3
SF - 1 1/8	ST - 3 1/4
SG - 1 1/4	SU - 3 1/2
SH - 1 3/8	SV - 3 3/4
SJ - 1 1/2	SW - 4
SK - 1 5/8	SX - 4 1/4
SL - 1 3/4	SY - 4 1/2
SM - 1 7/8	SZ - 4 3/4

(4) One digit designates motor speed (number of poles)

2 - 3450 RPM	6 - 1075 RPM
4 - 1725 RPM	8 - 825 RPM

(5) One or two letters designate application type

- A - Early designs, can be either pump or blower motors
- C, CA - Base mounted motor
- D, DA, DB - C Flange pump motors and partial pump motors
- E, EA, EB, EC - Special flange pump motors
- F, FA, FB, FC - Special flange pump motors
- L - Rigid sleeve bearing
- MA - Self align, sleeve bearing, non-thru bolt construction
- MB - Self align, sleeve bearing, thru-bolt construction
- N - C flange swimming pool pump motors
- P - Special flange pump motors
- S - Special flange pump motors
- T - Base mounted motors
- U - C flange pump motors
- V - Ball bearing construction

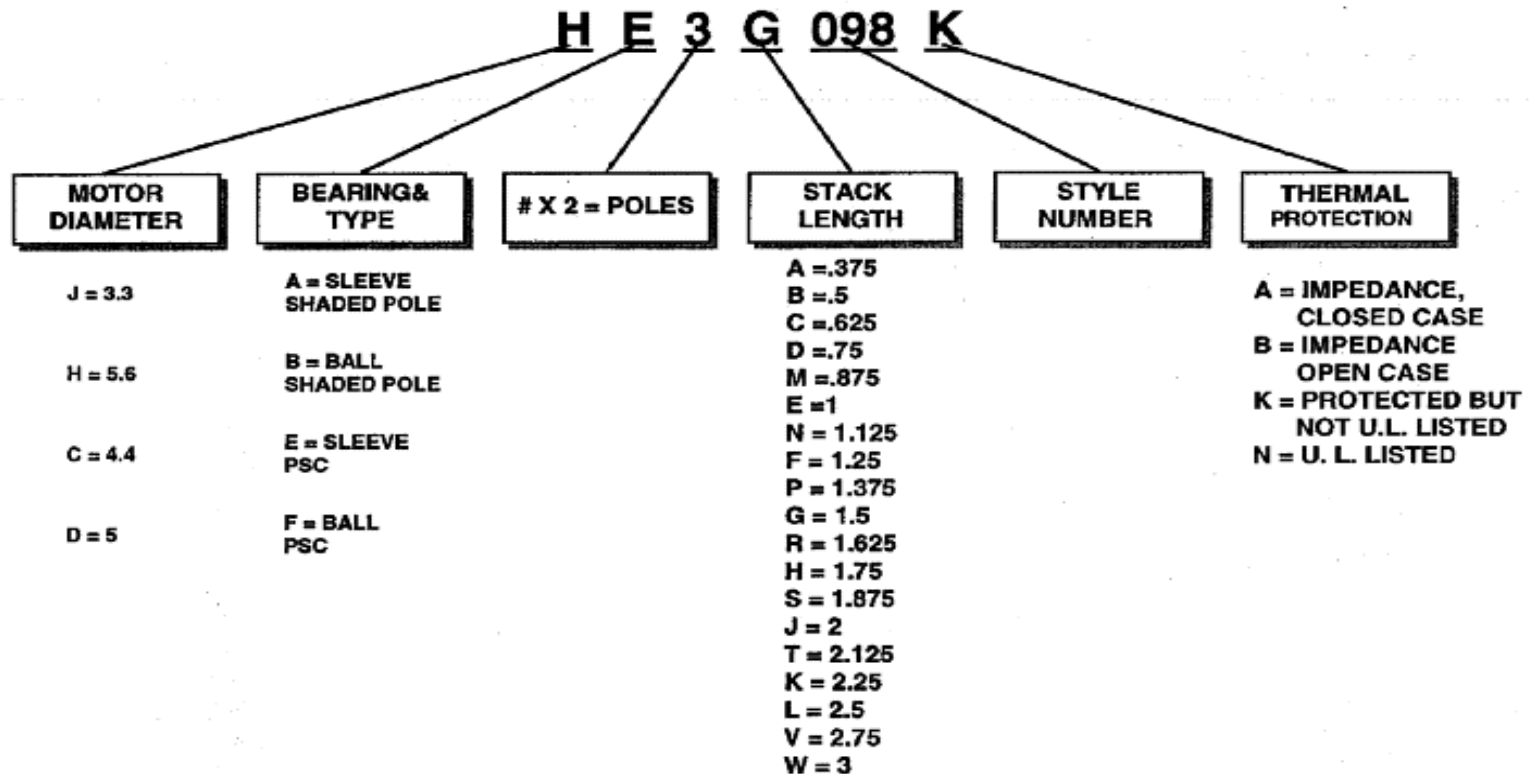
(6) One, two or three digits designate features too numerous to list

(7) One letter and one or more digits designate modifications

- A - Mechanical modification
- B - Electrical modification
- C - Mechanical and electrical modifications

Nameplate - Story

MAGNETEK/UNIVERSAL MODEL NUMBERS



Nameplate - Story

MARATHON

HOW TO READ A MODEL NUMBER

Each Marathon Electric motor carries a model number that can be used to define some of the motor's physical and electrical characteristics.

Example (For Fractional): 1PC48C17D2000AP

This is a breakdown of the model on the nameplate:

1	P	C	48	C	17	D	2000	A	P
1	2	3	4	5	6	7	10	11	

This is a breakdown of the model in the catalog:

P	48	C	17	D	2000
2	4	5	6	7	10

Example (For Integral): 2QA215TBDR A7076ALL

This is a breakdown of the model on the nameplate:

2	Q	A	215	T	B	D	R	A	7076	A	L
1	2	3	4	5	6	7	8	9	10	11	

This is a breakdown of the model in the catalog:

Q	215	T	B	D	R	A	7076
2	4	5	6	7	8	9	10

1. **Date Code** - Year of Manufacture (Not shown in catalog listings.)

2. **Thermal Protection:**

	UL RECOGNIZED		NON-UL RECOGNIZED	
	Motor Protector Combination	Motor Construction	Motor Protector Combination	Motor Construction
Automatic Reset				
Q	X	X	—	—
S	—	—	X	X
U	—	X	X	—
W	*	X	—	—
Manual Reset				
P	X	X	—	—
Z	—	X	X	—
X	—	—	X	X
No Reset				
V	—	X	—	—

* Motor protector combination is U.L. recognized only if motor is used in direct drive fan duty application, and is under locked rotor condition, or is running under no-load condition.

3. **Date Code** - Month of Manufacture (Not shown in catalog listings.)

4. **NEMA Frame Size** - (TS and US designate short shaft.)

5. **Electrical Type:**

A = Permanent split capacitor
 B = Capacitor start, capacitor run
 C = Capacitor start, induction run
 N = Split phase start, capacitor run
 S = Split phase
 T = Three phase
 H = Inverter Duty

6. **RPM or Speed (Fractional Only):**

34 = 2-Pole, 3600 rpm
 17 = 4-Pole, 1800 rpm
 11 = 6-Pole, 1200 rpm
 8 = 8-Pole, 900 rpm

7. **Enclosure:**

D = Dripproof
 E = Explosion proof, non-ventilated
 F = Totally enclosed, fan cooled
 G = Explosion proof, fan cooled
 O = Open
 P = Partial
 S = Semi-enclosed
 T = Totally enclosed non-ventilated

8. **Frame Construction (Integral Only):**

L = Aluminum (Full Frame)
 Y = Aluminum (Redesign - Full Frame)
 Z = Aluminum (Redesign - High Mount Down Frame)
 R = Rolled Steel (Full Frame)
 W = Rolled Steel (Redesign - Full Frame)
 X = Rolled Steel (Redesign - High Mount Down Frame)
 S = Cast Iron (Full Frame)
 N = Cast Iron (Redesign - Full Frame)
 P = Cast Iron (Redesign - High Mount Down Frame)
 C = Cast Iron - Sourced (Full Frame)

9. **Style Letter**

10. **Sequence Number - Last 3 Digits (Integral Only)**

001-025 = 2-Pole, 3600 rpm
 026-075 = 4-Pole, 1800 rpm
 076-100 = 6-Pole, 1200 rpm
 101-125 = 8-Pole, 900 rpm

11. **Manufacturing Code**

Nameplate-Story

Emerson Born on Date Code

- Example: XA96X

This Product Was Manufactured in Jan 1996

A= January B= February, Etc. "I" Is
Skipped

X= Possible Plant Codes Which May or May Not Be
Present

Nameplate-Story

HORSEPOWER

- Is an indication of the motor's strength.
- Catalog motors are honest about this.
- OEM motors sometimes fib.
- Beware of "SPL" after HP
- Can be marked as multiple for multiple speeds (1/2-1/3-1/4)
- Use the same or greater for replacement.

Nameplate-Story

SERVICE FACTOR

- Factor indicating how much extra Horsepower the motor can deliver without overheating.
- Service Factor HP = HP X SF.
- 1 HP with 1.15 Service Factor can carry 1.15 HP.
- Don't replace a motor with a service factor with a motor without a service factor with the same HP.
- You could replace a 1/4 HP with a 1.35 SF with a 1/3 HP with no SF.

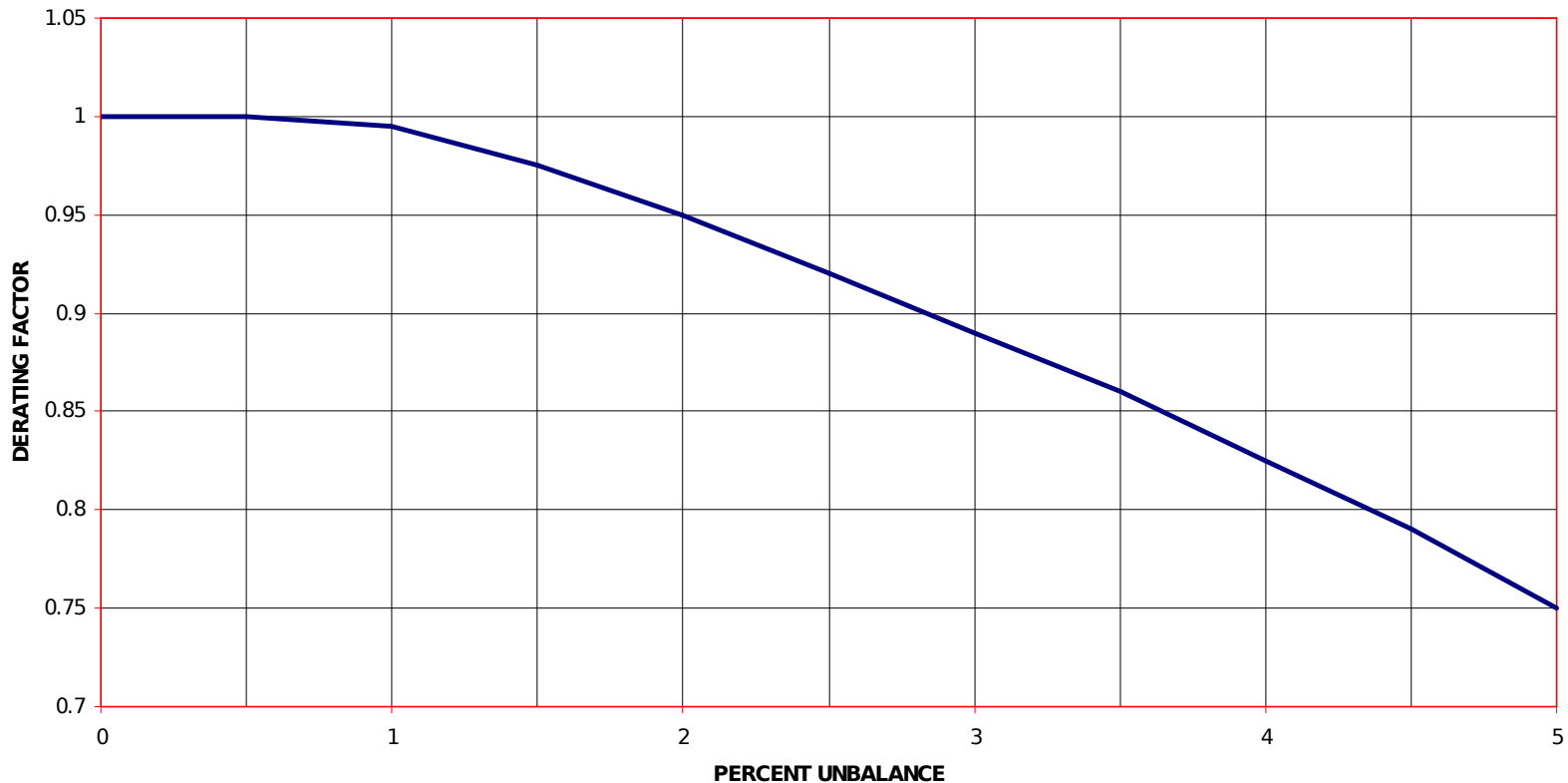
Nameplate-Story

VOLTAGE

- Normal operating voltage.
- Motor should work within 10%.
- Only operate motors rated 208 when volts are less than 208.
- Or use next highest HP 230 volt motor.
- Or use motor with Service Factor.
- Hi or Low voltage can cause protector trips.
- Slash (/) indicates different connection (115/230).
- Dash (-) indicates a range or voltage (208-230).
- 3 Phase motors cannot tolerate voltage unbalance. NEMA specifies <1%.

Voltage - 3 Phase Unbalance

DERATING DUE TO VOTAGE UNBALANCE



Avg. of Phase 1, 2 & 3 = X; Phase/X = % Unbalance

Avg. of 220, 225, 230 = 225; % Unbalance = $220/225 = 2.3\%$



EMERSON
Climate Technologies

Nameplate-Story

AMPS

- Approximate Current Draw at Full Rated Horsepower.
- Regarded As a Good Indication of Motor Strength
 - Replacements Could Be 20% Less Due To:
 - Better Efficiency
 - Better Power Factor
 - Larger MFD Capacitor
 - » Especially on 115 Volt PSC Motors
- Best Way to Tell If the Motor Has Been Properly Sized.
- Measured Amps Versus the Nameplate
 - Should Be -25% to +10%.
 - Outside of This, the Motor Is Mis-sized.

Nameplate-Story

Service Factor Amps.

- Current draw when the motor is loaded to the Service Factor.
- Should not be exceeded.

Nameplate-Story

RPM

- Indicates approximate speed under load.
- Actual may be 1 to 10% different.
- Load determines speed.
- Marked Hi/#speeds (1075/3spd) or Hi/Lo (1725/1140).
- Multi-speed PSC motors are really multi-HP. Load determines speed.
- Never replace 1050-1100 with a 1625.
- Beware of motors with Non-typical RPM.

Nameplate-Story

Typical Nameplate RPM

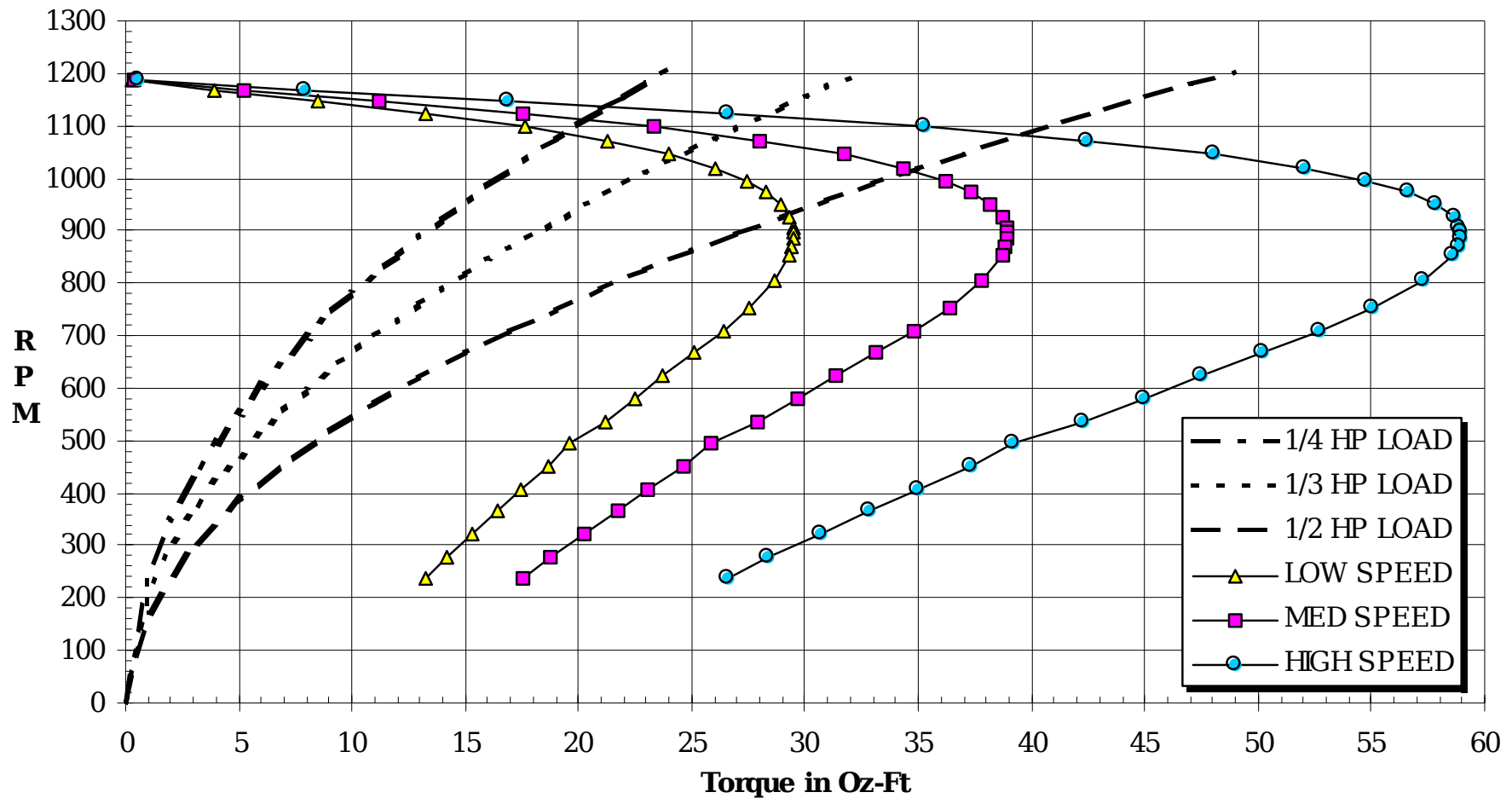
# Poles	Synchronous or No Load	Typical Nameplate			
SP	PSC	Others			
2	3600	3000	3250	3450	
4	1800	1550	1625	1725	
6	1200	1050	1075	1140	
8	900		800	825	850

Based on 60HZ, Synchronous= $7200 / \# \text{ Poles}$

Nameplate-Story

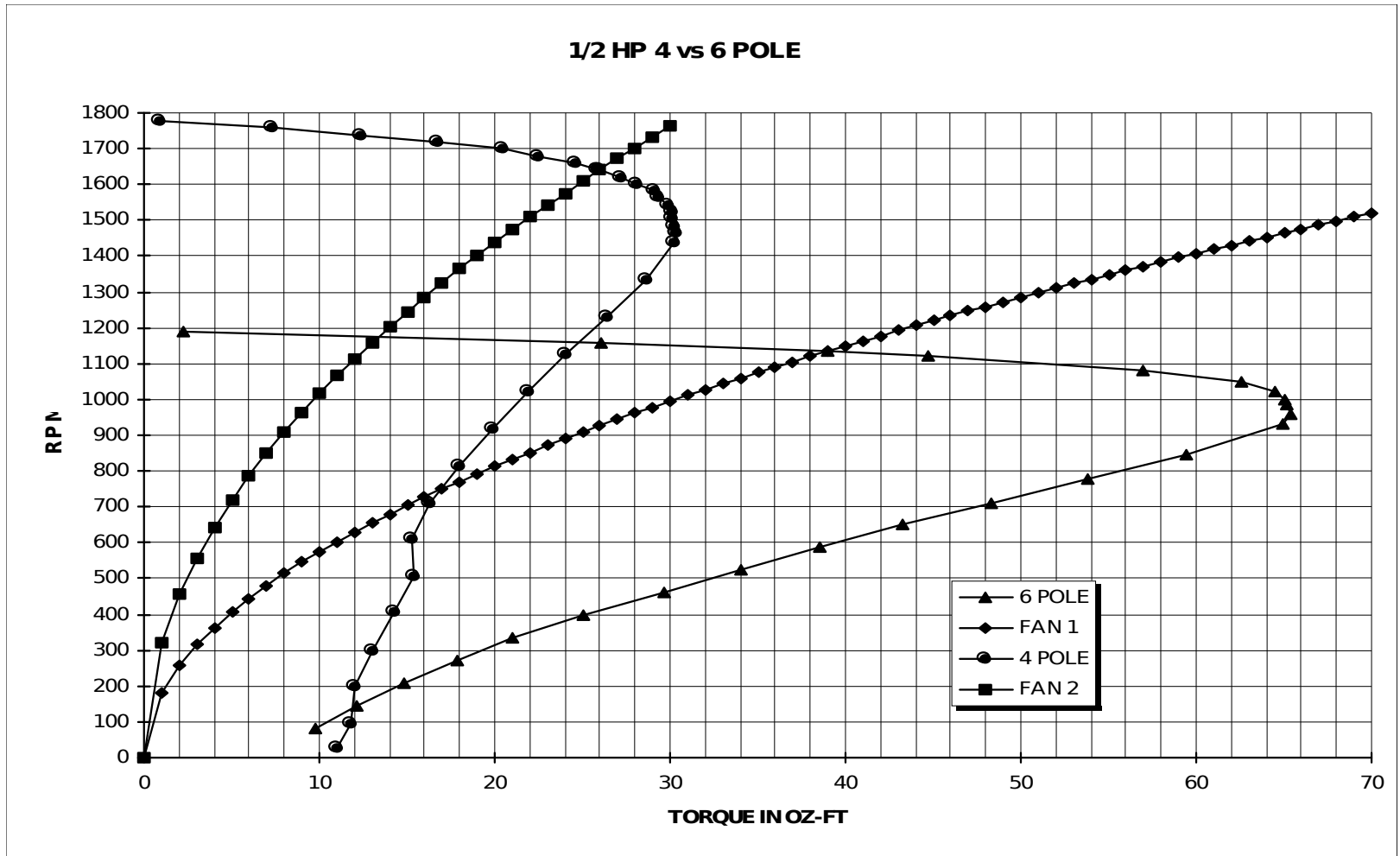
Load Determines the Speed

1/2 HP 6 POLE 3 SPEED MOTOR vs LOAD



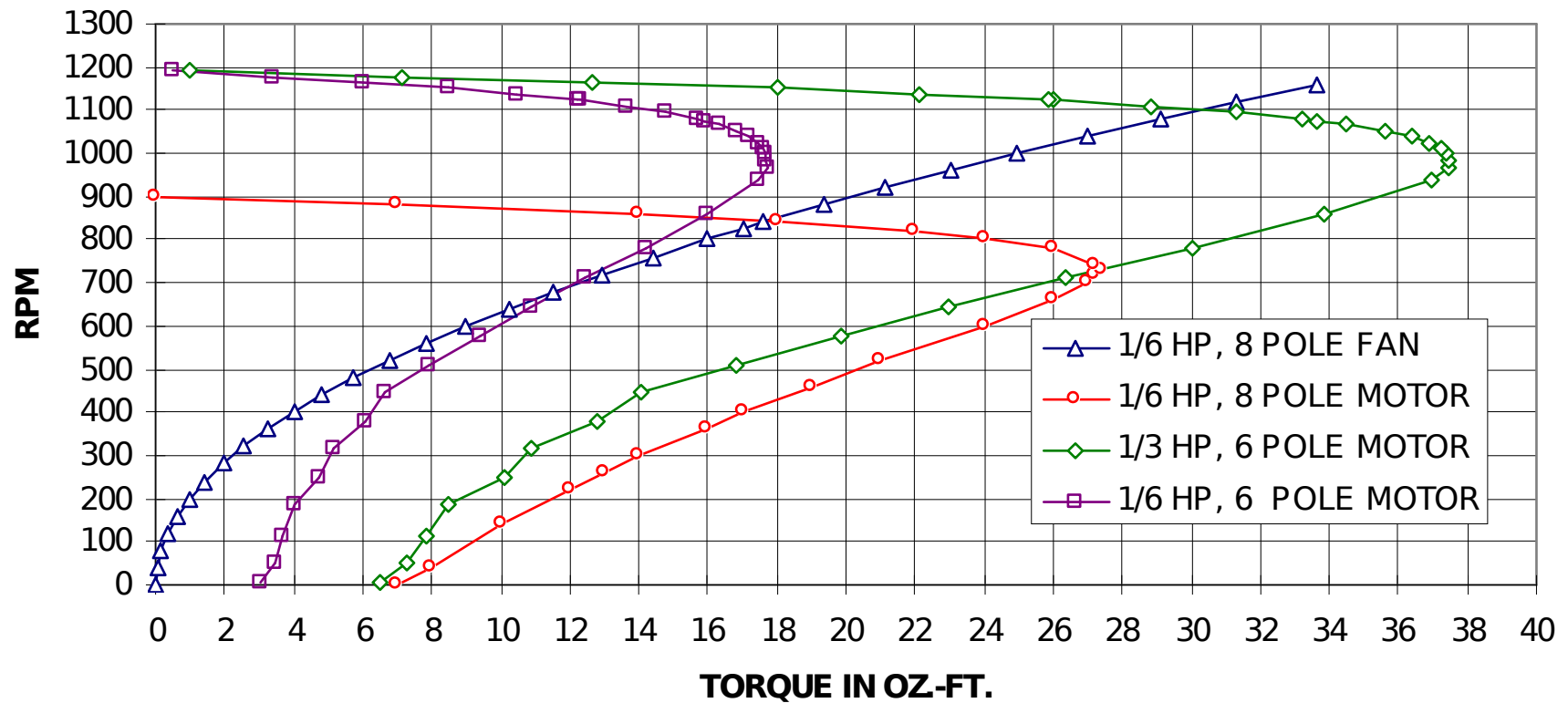
Nameplate-Story

4 Pole Versus 6 Pole



Nameplate-Story

8 POLE CONDENSER FAN REPLACE BY 6 POLE



Nameplate-Story

PH - Phase

- Either “1” or “3” and indicates if motor is single or three phase.
- A three phase motor cannot be used on single phase.
- A single phase motor can be connected across one of three phases.

Nameplate-Story

HZ - Hertz

- Used to be Cycle per second.
- Is the amount of alternations per second that “AC” Voltage has.
- In North America and some other places, it is 60. Most of the rest of the world, it is 50.
- Determines how fast an induction motor will run. Motor run on 50 HZ. Runs 5/6 slower than of 60 HZ. Also runs hotter.

Nameplate-Story

Time Rating

- “Cont.” For Continuous
- Most Motors Are Rated Continuous
- Except for Gear and Garage Door Motors.
- Continuous Air Over or Air Over Continuous
 - There Must Be Air Over or Motor Will Overheat and Trip.

Nameplate-Story

Insul. Class B (or A) or Ins CL B (or A)

- Total Temperature of Windings
 - Heat Generated by the Motor (Rise) Plus
 - Heat of the Surroundings (Ambient Temperature).
- Class A Is 105C (221F): Rise + Ambient
- Class B Is 130C (266F): Rise + Ambient
- Class F Is 155C (311F): Rise + Ambient

Nameplate-Story

AMB. - Ambient

- Max Temperature of the Air Around the Motor.
- If Exceeded Motor Will Overheat.
- Most Motors Are Rated 40C (104F).
- Some Condensers Motors Are Rated 60C (140F)
 - Superheated Air Produced by the Coils.
- 140F / 60C Ambient Motor Has:
 - Lower Temperature Rise
 - Longer Life at Lower Ambient
 - Exceeds OEM Design Temp of 135F Maximum

Nameplate-Story

Thermally Protected

- Motor Has Internal Thermal Protector.
- All Heating and Air Conditioner Motors Should Have Thermal Protection.
- Most Use Automatic.
- Don't Use Automatic in Power Tools.
- Protector Tripping Is Usually a Sign of:
 - Motor Is Being Overloaded
Being Used in the Wrong Application.
- Protector Tripping Can Be an Indication That:
 - Something Is Wrong With the Motor
 - Or Capacitor
- Never Wire Around a Protector.

Code Letter

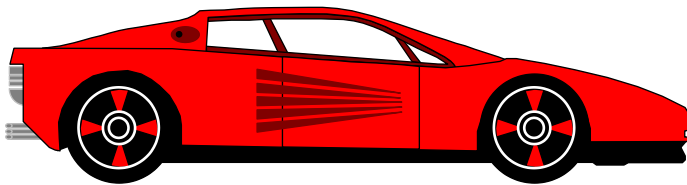
Code	KVA/HP	Approximate Mid-Range Value
A	0.00-3.14	1.6
B	3.15-3.54	3.3
C	3.55-3.99	3.8
D	4.00-4.99	4.3
E	4.50-4.99	4.7
F	5.00-5.59	5.3
G	5.60-6.29	5.9
H	6.30-7.09	6.7
J	7.10-7.99	7.5
K	8.00-8.99	8.5
L	9.00-9.99	9.5
M	10.00-11.99	
10.6		
N	11.20-12.49	
11.8		
P	12.50-13.99	
13.2		
R	14.00-15.99	
15.0		

Locked Amps = Value X HP/ Kvolts

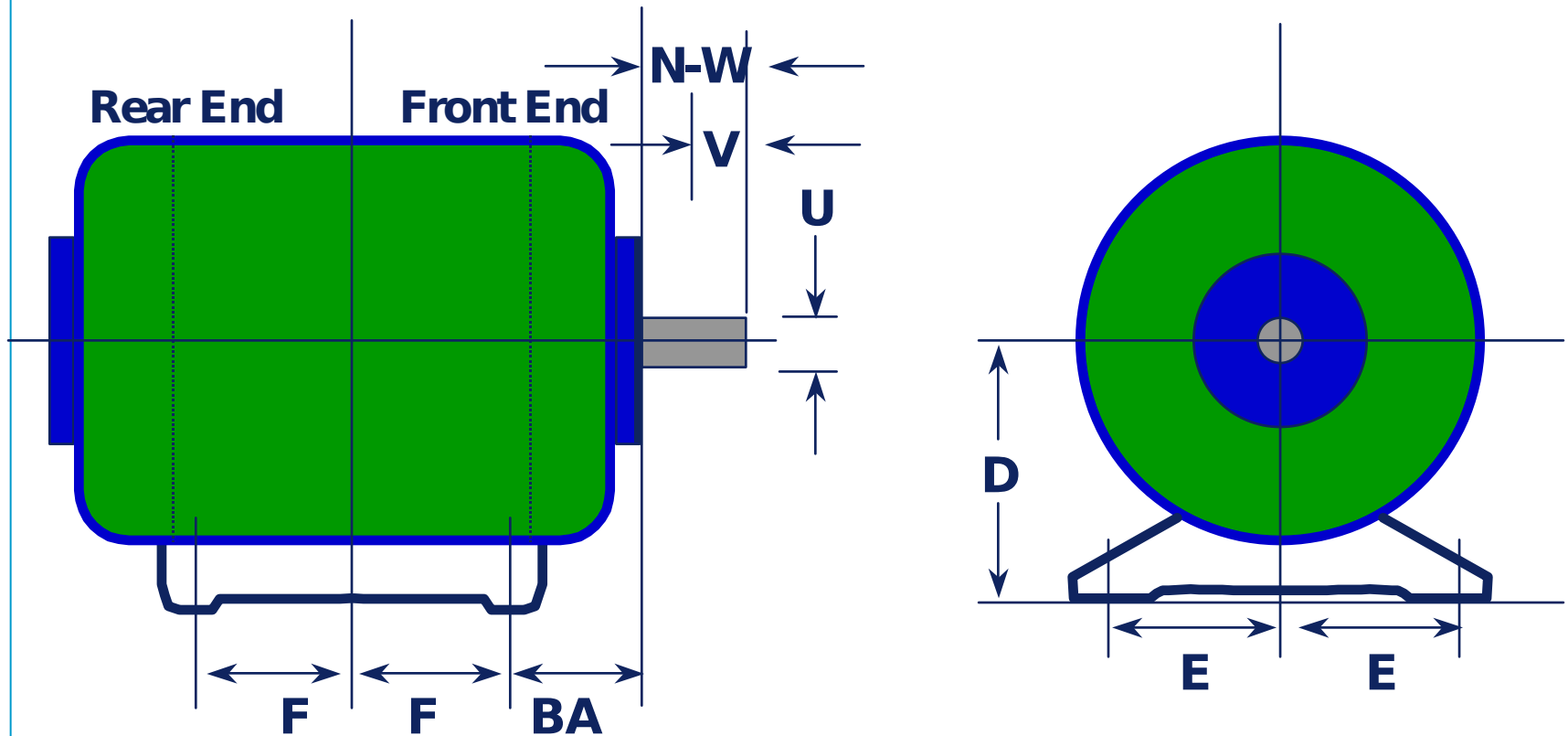
$$41.3 = 9.5 \times 1 \text{ HP} / 0.230 \text{ Kvolts}$$

Motor Lubrication

- **Prelubricated Bearings**
 - **No further Lubrication Required**
- **Reoil Bearings SAE 20 Oil**
 - » **Continuous Duty : Every Year**
 - » **Intermittent Duty : Every 2 Years**
 - » **Occasional Duty : Every 5 Years**



NEMA Mounting Dimensions



“D” Dimension - Shaft Height - is Key

Nameplate-Story

NEMA Frame sizes

- Number Is the # 1/16's of an Inch to the Shaft Height. $56/16 = 3.5''$
- For Larger Frames, Like 140, the First Two Digits Are the # of 1/4'S of an Inch $14/4 = 3.5''$ Too.
- A Letter After the Nema Frame Code Describes a Special Frame.

Example: 56C

Suffix = C - Face Mounting

H - "F" Dimension Larger Than Standard

J - Jet Pump

L - Home Laundry

M - Oil Burner, 5 1/2" Flange

N - Oil Burner, 6 3/8" Flange

Y - Special Mounting Dimensions

Z - Special Shaft Extensions

B - Carbonator Pump

The Unknown Soldier

Many times a failed motor will have no nameplate or the nameplate may have deteriorated so badly that it is not longer legible.

In those cases, how do you determine a suitable replacement?

With a little detective work and the following rules, you can pick a motor which will do the job.

Identifying the Unknown Soldier

These are the things you will need to know when you try to replace a motor which has no legible nameplate.

Diameter _____

Motor Type:

Shaded Pole

Split Phase

Perm. Split Cap

Cap. Start

Other

Application _____

Enclosure _____ Protection _____

Speed _____ # of Speeds _____

H.P. (Stack) _____

Rotation _____ Voltage _____

Shaft and Bearings _____

Mounting _____

Unknown Soldier

Motor Diameter

Measure across the stator to determine the diameter.

Common diameters are 4.9" to 5",
5.5" to 5.6" and 6.3" to 6.5".

For unknowns, always use the same diameter replacement.

Unknown Soldier

Motor Type

- For Unknowns Always Use the Same Type Motor for Replacement.
- Starting Switch and No Capacitor = Split Phase
- Starting Switch and One Capacitor = Capacitor Start
- Starting Switch and Two Capacitors = Capacitor Start-capacitor Run
- One Distinct Set of Windings = Shaded Pole.
- Two Distinct Set of Windings = Permanent Split Capacitor or PSC
- Two or More Distinct Sets of Windings and Many Black Leads = Three Phase

Unknown Soldier

Application

- Knowing the Application
 - Helps Narrow Down Choices
 - Helps Assure That the Right Motor Will Be Chosen
 - Furnaces Will Usually Be a Belted Fan or Direct Drive PSC Blower Motor.
 - Condenser Fan Motor Will Usually Be a Direct Drive PSC Motor.

In Any Case, Use a Motor Which Was Designed for the Application.

Unknown Soldier

Enclosures

- In the Case of the Unknown Soldier, You Must Match the Enclosure (Ventilation.) because a motor with more open vent holes usually does not need as much stack to produce the required horsepower

Unknown Soldier

Enclosure Types

- Shaft Up
 - All holes are at end opposite shaft.
- Shaft Down
 - All holes are at shaft end.
- Totally Enclosed Air Over- TEAO
 - Air Over needed.
- Totally Enclosed Non Ventilated-TENV
 - Air Over not needed.
- Totally Enclosed Fan Cooled-TEFC
 - Motor has its own fan on the back of the motor.
- Open or Open Air Over-OAO;
 - Open Air Over needs air.
- Open Drip Proof-ODP
 - All openings are below horizontal centerline. 15 degree drip cannot hit windings.

Motor Enclosures



Open (OP)



Open Drip Proof (ODP)



**Totally Enclosed
Air-Over (TEAO)**



**Totally Enclosed
Non-Vented (TENV)**



**Totally Enclosed
Fan Cooled (TEFC)**



**Hazardous Location
Totally Enclosed Fan
Cooled (HAZ-LOC, TEFC)**

Unknown Soldier

Protection (Thermal)

Always Use the Same Type of Thermal
Protection As the Motor to Be
Replaced.

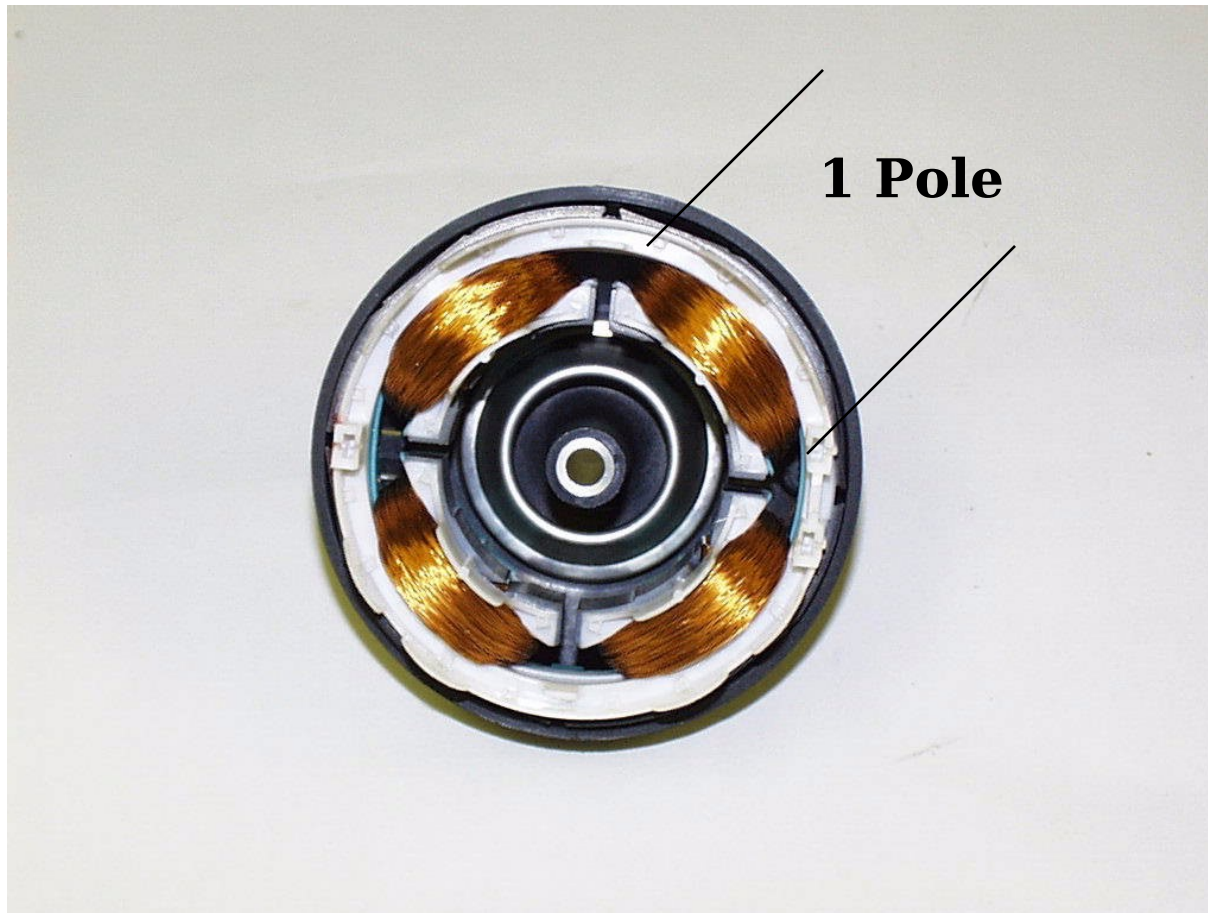
Unknown Soldier

Speed/Speeds

- You Must Replace the Unknown With the Same Number of Poles.
- Count the Poles. See the Attached Pictures.
- To Determine the Number of Speeds:
 - Count the Leads.
 - Shaded Pole or PSC With Capacitor:
 - $\text{Speeds} = \text{Leads} - 1$.
 - For PSC, With Two Capacitor Leads (Two Leads Same Color, Usually Brown):
 - $\text{Speeds} = \text{Leads} - 3$. (Mostly Blowers, Furnaces and Air Handlers)
 - For PSC, With One Capacitor Lead (No Two Leads Same Color):
 - $\text{Speeds} = \text{Leads} - 2$ (Mostly Condenser Fans and RAC's).

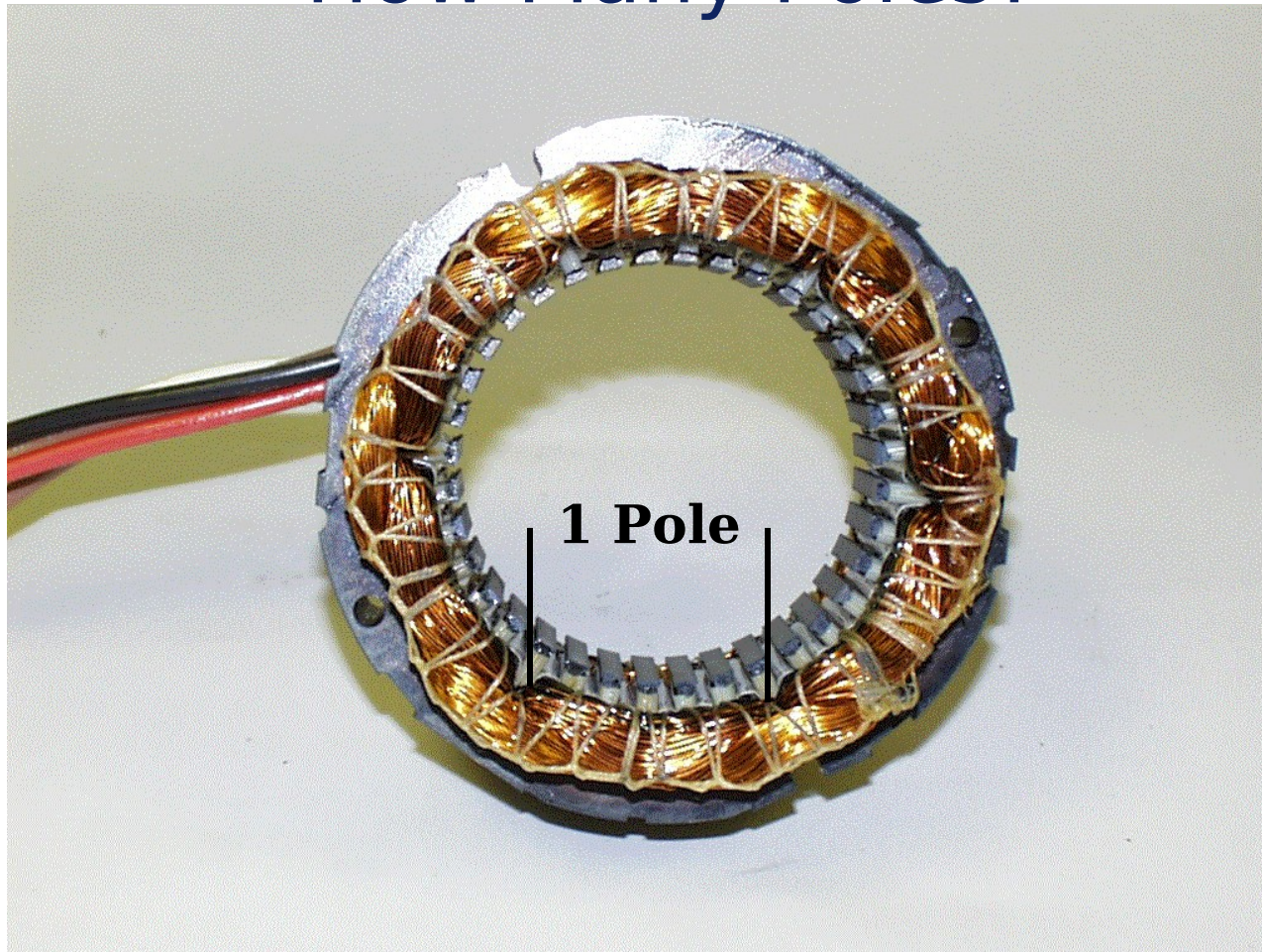
Unknown Soldier

Shaded Pole Motor
How Many Poles?



Unknown Soldier

PSC Motor
How Many Poles?



Unknown Soldier

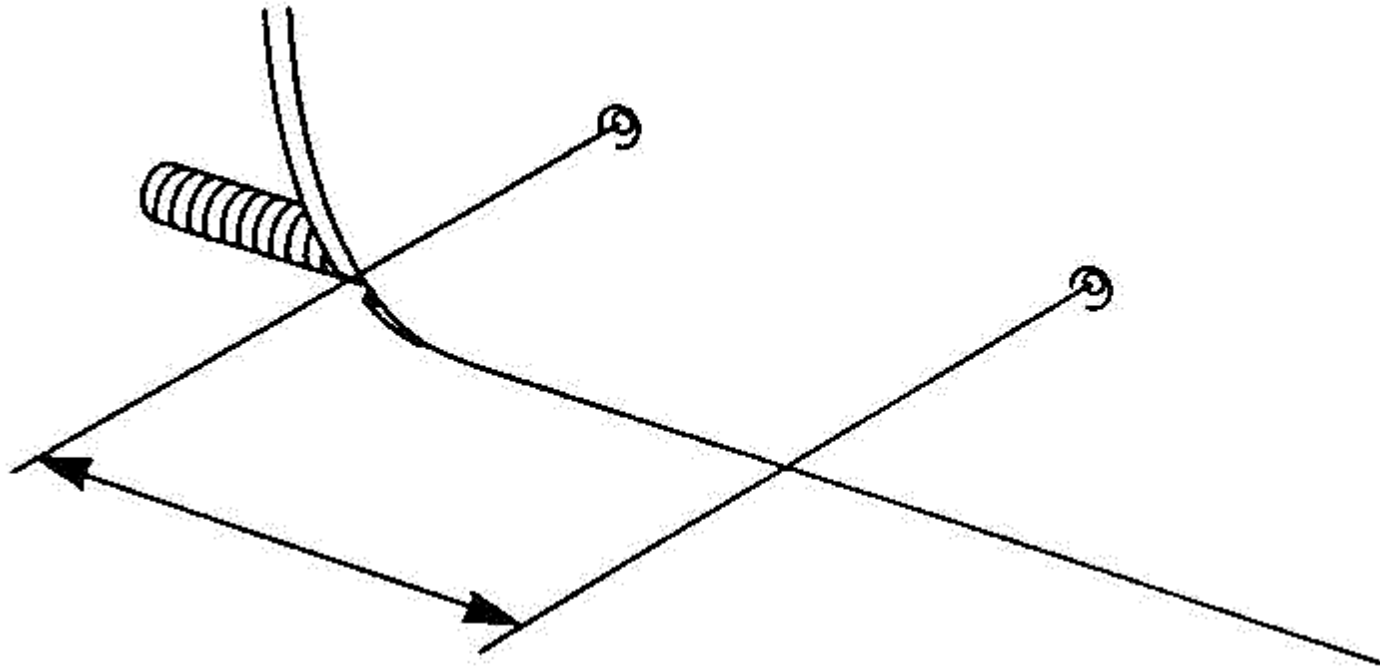
Horsepower

If there is no nameplate, you must estimate the horsepower as follows:

- Measure the length of the stator stack. You can also get a close estimate from the press marks on the shell.
- Replace same stack with same or greater stack and same ventilation.
- In the same application, speed and ventilation, stack measurement is the most accurate way of judging motor strength.

Unknown Soldier

STACK LENGTH DIMPLES



Unknown Soldier

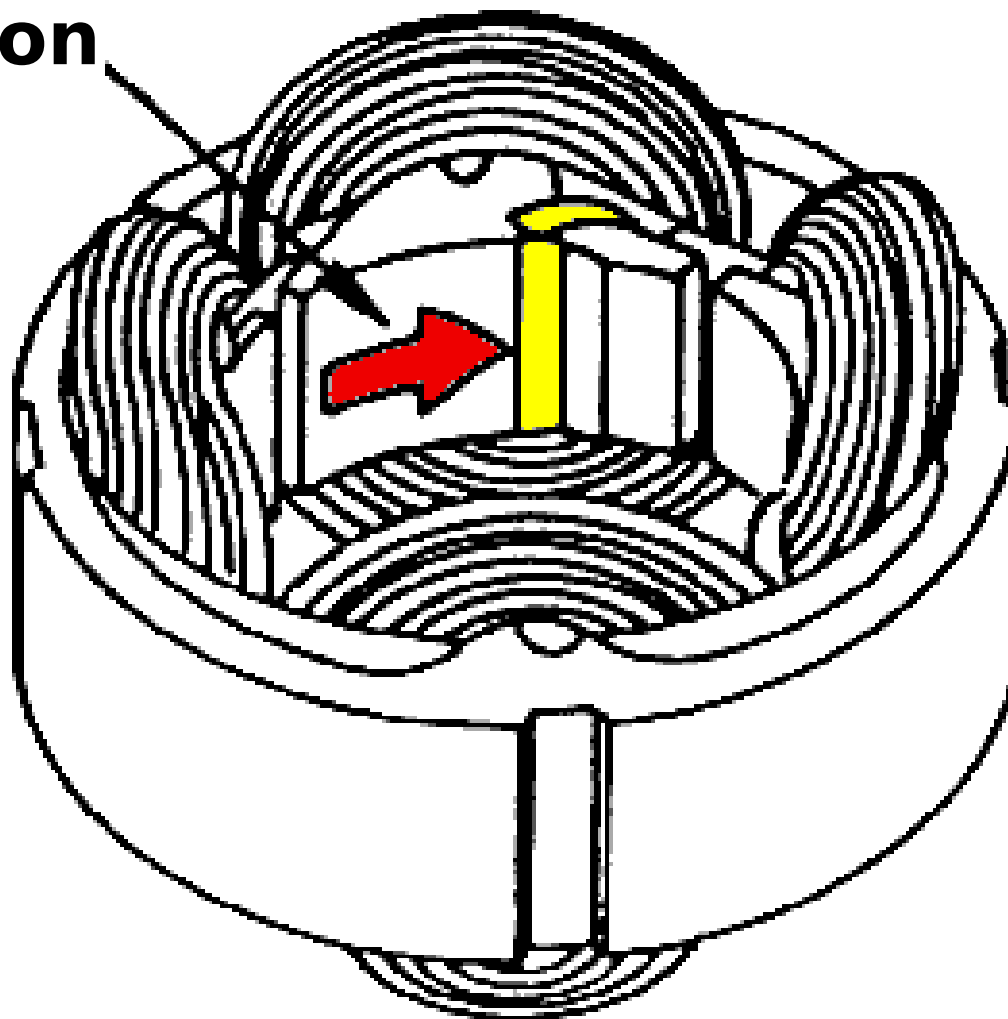
Rotation

- This is not usually critical because:
 - Most replacements are reversible, except for shaded pole.
 - Shaded Pole: Will rotate toward the shading coil.
 - If you really need to know for others:
 - Split Phase: Check for dust on the leading edge of the rotor.
 - Capacitor Start: Same as split phase.
 - Permanent Split Capacitor: Same as Split phase. If no dust or fins, your SOL.

Unknown Soldier

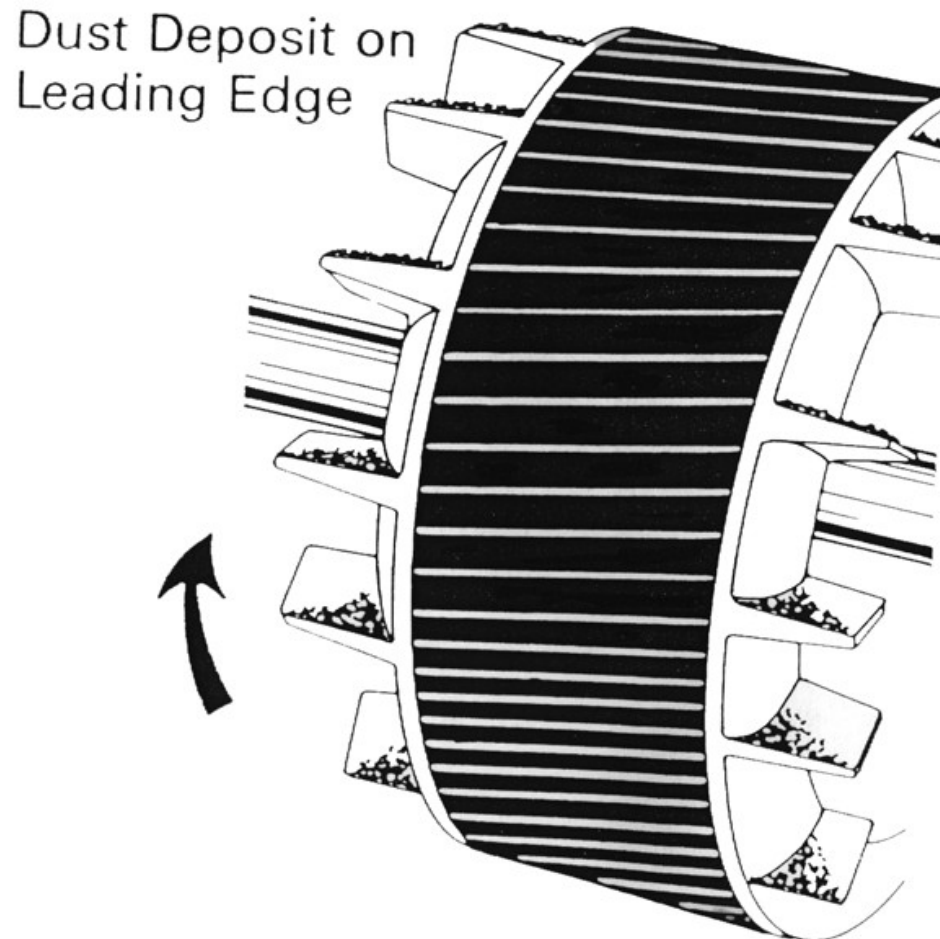
Shaded Pole Rotation

Rotation



Unknown Soldier

Rotation



Unknown Soldier

Voltage

- Really no way to tell by looking at the motor. The service technician must make this determination. However:
 - Residential Air Conditioning equipment is normally 208-230V.
 - Heating equipment is normally 115V with the exception of electric furnaces which are often 230V.
 - Gas / Oil Furnace will usually be Belted Fan or Direct drive PSC blower, 115 volt.
 - Residential Condenser Fan motor will usually be Direct drive PSC motor, 208-230 volt

Unknown Soldier

Shaft and Bearings

- Measure shaft diameter.
- Use adapter sleeves in catalog to increase diameter.
- Replace ball bearing motors with ball bearing motors.
- Ball bearing motor can be used to replace sleeve.

Unknown Soldier

Mounting

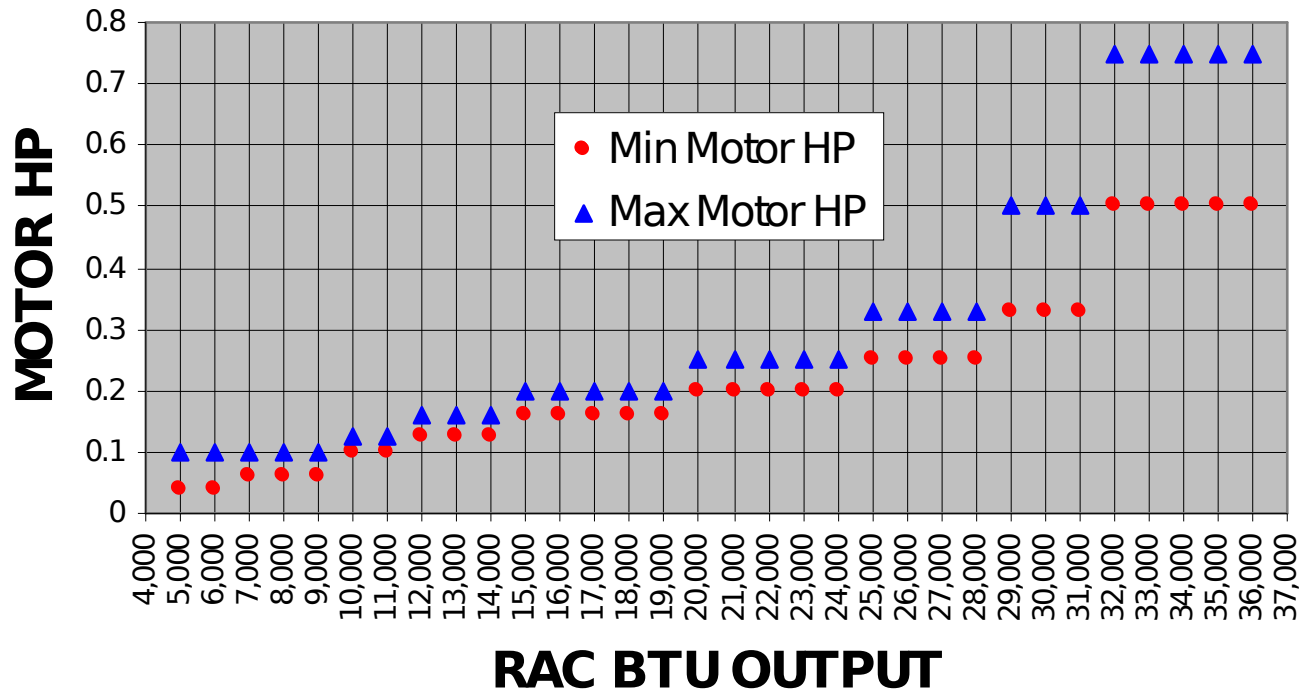
- This May Be a Show Stopper. If You Can't Duplicate Mounting, It Won't Work.
- Many Kits Are Available to Help You.
 - Rigid Base
 - Resilient Cradle
 - Ear (Lug) Mount
 - Flange Mount
 - Extended Through-bolt
 - Belly Band
 - Adjustable Steel Bracket

Horsepower vs. BTU's

Central A/C System Condenser Fan Motors	
System	HP
2 TON	1/5
2 1/2 TON	1/4
3 TON	1/3
3 1/2 TON	1/2
4 TO 5 TON	3/4
7 1/2 TON	1

Horsepower vs. BTU's

RAC BTU's vs MOTOR HP



Horsepower vs. Fan

3 Blades			
Dia.	Blade Angle	HP for 1140 RPM	HP for 850 RPM
18	27	1/6	1/10
18	30	1/5	1/10
18	33	1/4	1/5
20	27	1/4	1/5
20	30	1/3	1/5
22	27	1/2	1/4
22	33	3/4	1/3
24	27	1/2	1/4
24	33	3/4	1/3

4 Blades			
Dia.	Blade Angle	HP for 1140 RPM	HP for 850 RPM
16	19	1/12	1/35
16	23	1/8	1/15
16	27	1/6	1/10
16	33	1/5	1/10
18	27	1/5	1/10
18	30	1/4	1/5
18	33	1/3	1/5
20	23	1/4	1/5
20	27	1/3	1/5
20	30	1/3	1/5
20	33	1/2	1/4
22	27	1/2	1/4
22	33	1	1/2
24	27	3/4	1/3
24	33	1	1/2
26	27	1 1/4	3/4
26	33	1 1/2	3/4

5 Blades			
Dia.	Blade Angle	HP for 1140 RPM	HP for 850 RPM
16	33	1/4	1/5
18	33	1/2	1/4
20	33	1/2	1/4

Fan Law:
 $(RPM1/RPM2)^3 = HP1/HP2$

Catalog Help

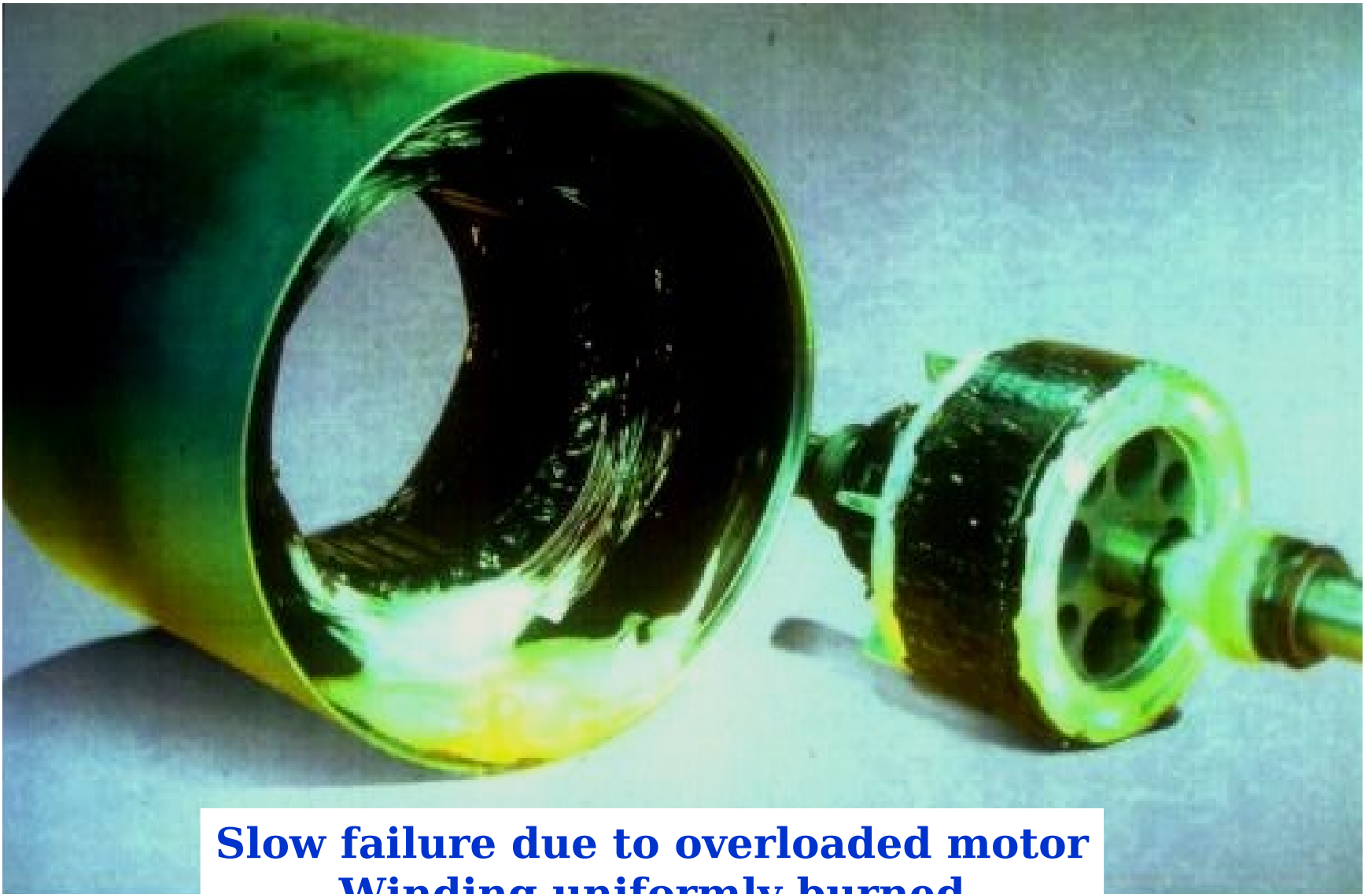
Most Motor Catalogs Contain a Lot of good Information.

“You can observe a lot by just lookin”

- Cross references
 - By OEM Model
 - By OEM Part Number
 - By Competitive Catalog Number
- Motor Selection Information



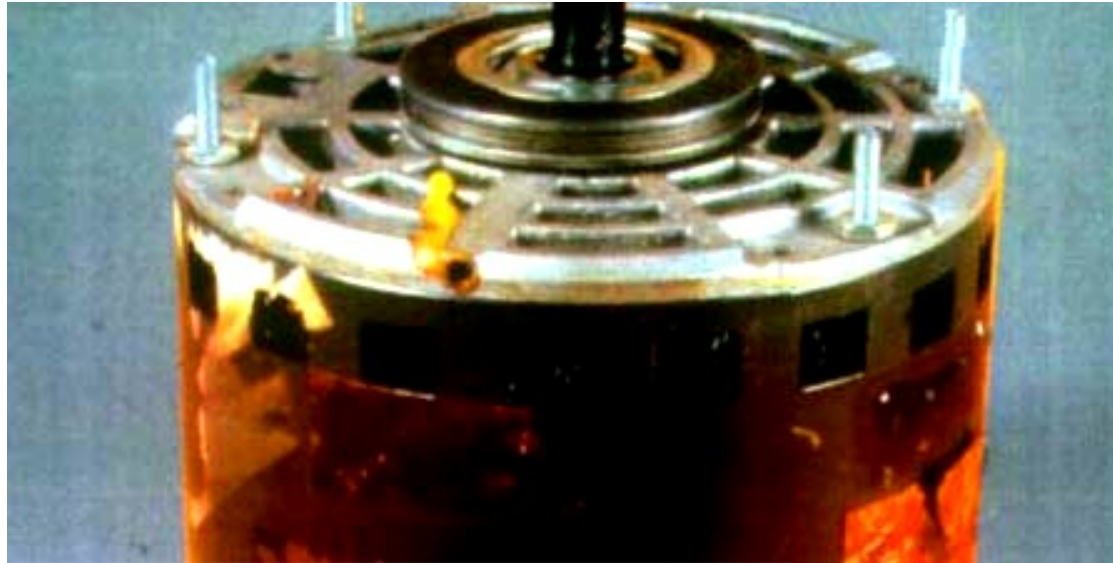
Rotor Strike due to bearing failure



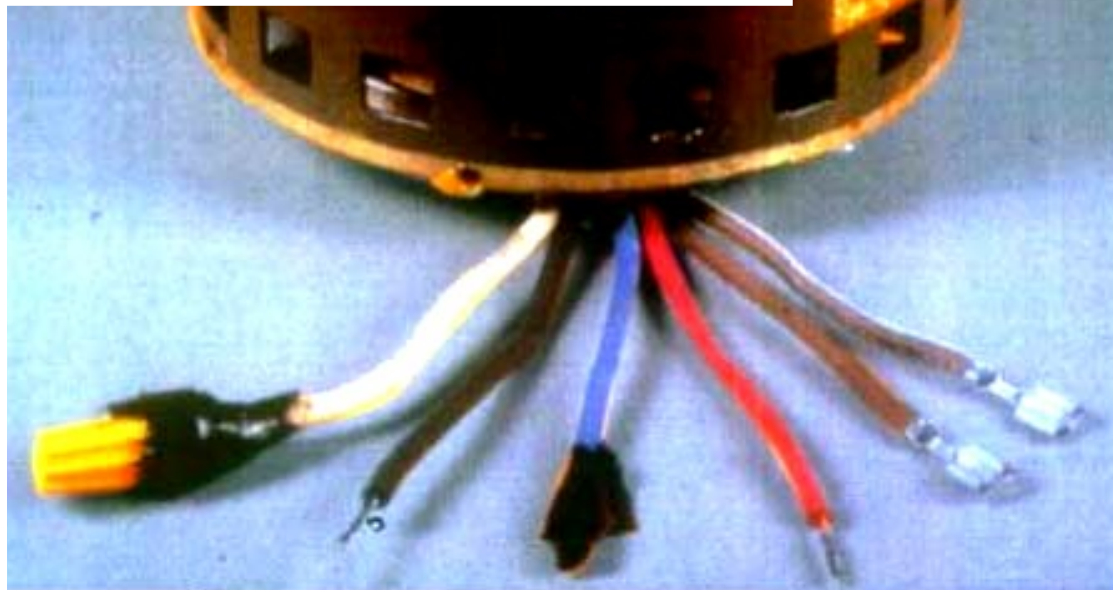
**Slow failure due to overloaded motor
Winding uniformly burned**

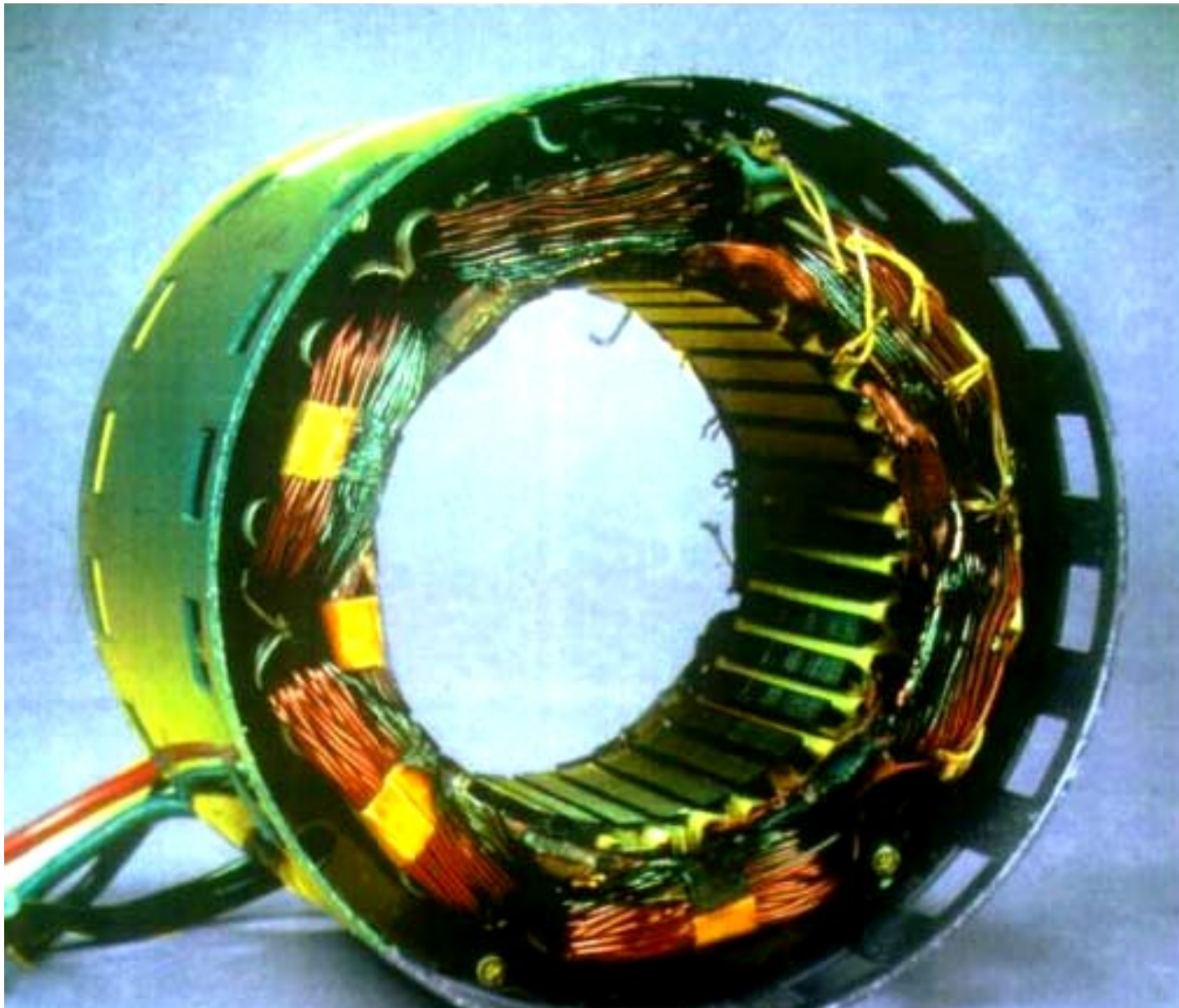


Starting winding failure, probably due to switching mechanism fail



**anger sign - Used wrong leads in wiring
High (Black) & Low (Red) speeds**





er put to Black and Red (vs White) create low speed winding fail



Failure in one place, possible water or assembly issue



Motor not oriented correctly for drainage causes winding failure.



part winding burned due to actuator staying open, snake interfer